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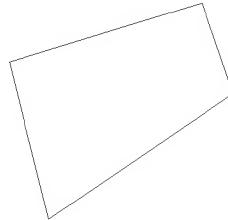


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Worldwide Tank Fire-Control Systems

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*SW 83-10068
November 1983*

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Worldwide Tank Fire-Control Systems

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This paper was prepared by [redacted]
Office of Scientific and Weapons Research.
Comments and queries are welcome and may be
directed to the Chief, General Purpose Weapons
Branch, OSWR, [redacted]

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SW 83-10068
November 1983

Worldwide Tank Fire-Control Systems

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Preface

*Information available
as of 5 July 1983
was used in this report.*

Many countries are importing sophisticated fire-control devices and significantly upgrading their aging tank fleets. Additionally, newer tanks already equipped with modern fire-control systems are being exported worldwide. Fire-control systems determine tank accuracies and firing rates and extend tank capabilities by enabling effective weapon firing at night, in poor visibility, at moving targets, or on the move. This reference aid describes the fire-control systems known to be deployed on main battle tanks (the tanks descended from the World War II class of medium tanks) throughout the world.

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Fire-control systems for heavy and light tanks are not discussed in this paper. Tanks classified as heavy have not been built for 20 years, although several new main battle tanks are actually heavier than the old heavy tanks. The heavy tanks—mostly Soviet T-10 and Josef Stalin (JS-1, 2, 3) tanks—probably are in service only in reserve units or in dug-in defensive positions. Light tanks weigh less than 25,000 kilograms. They are in widespread use, and some have sophisticated fire-control systems. But they do not have enough armor protection to withstand hits from main battle tanks. Examples of light tanks include the Austrian SK-105; Brazilian X1A1 and X1A2; British Scorpion; Chinese Types 62 and 63; French AMX-13; Soviet PT-76; and US M3, M5, M24, M41, and M551.

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**Worldwide Tank
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Organization and Definitions

In this reference aid, main battle tanks and their fire-control systems are arranged according to the national design origin of the tank.

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Each national section contains a:

- Brief history and identification of the different tanks designed by the topic country.
- Table providing the characteristics and designators, when known, of the tank weapons and fire-control systems.
- Discussion of the operation of the fire-control systems of the tanks.

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All of the tanks currently deployed, except the Swedish Strv-103B, are turreted designs. The crews of turreted tanks built since the 1950s have consisted of a commander and gunner in the turret, a driver in the hull, and usually a loader in the turret. The Strv-103B is turreted with an automatic gun loader (auto-loader). The Strv-103B crew consists of a commander, gunner-driver, and radio operator. The Soviet T-64, T-72, and T-80 series of tanks all have autoloaders and do not have the loader crewmember.

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Turreted-tank guns tilt on mountings in the turrets to elevate, and the turrets traverse—rotate on the tank hull—to swing the guns in azimuth. The objective of all tank fire-control systems is to traverse the turret and elevate the gun to the correct azimuth and elevation angles for the ammunition to hit a target.

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Throughout this paper, tank fire-control systems are described in a gunnery context unless a missile-firing tank is being discussed. Tank weapons are mainly large-caliber guns firing different types of ammunition. A few tanks have been designed to fire antitank guided missiles (ATGMs) and these have ATGM-guidance subsystems within their fire-control systems.

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Brazil

Secret**Brazil****X-30 Tank Project**

The Brazilian firm Bernardini is developing a 30-ton tank, referred to as the X-30 by the Brazilian press, for production in Brazil. Brazilian tank development officials have said that the X-30 will have a 105-mm or 120-mm gun of European design, but, in press reports, European officials have denied any involvement in the project. Specifications for the fire-control system for the X-30 cannot be completed until the Brazilians have chosen the gun for the tank and are closer to production. [redacted]

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Brazil can choose among several possible fire-control systems for the X-30. It may choose a relatively simple system, consisting of a coaxial telescope on the gun and manually cranked turret-traverse and gun-elevation gears. Brazil has produced similar systems for other indigenously developed armored fighting vehicles. [redacted]

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If Brazil chooses a more sophisticated fire-control system, it would probably have to import some of the components. Brazilian firms have experience in tank and tank gun production, but we do not know the extent of their expertise in fire control. Bernardini has rebuilt Brazil's US-made M3A1 Stuart light tanks into the X1A, X1A1, and X1A2 light tanks. The Brazilian firm Engesa has built 90-mm guns under license, such as the French-designed D921 and Belgian-designed Cockerill Mark 2, for the Brazilian light tanks and reconnaissance vehicles. The EE-9 Cascavel, an armored car built by Engesa, is offered with an Nd:YAG laser rangefinder, the LV3 built by the British firm Avimo. The Brazilians have stated an interest in night sights after the successful night tactics used by the British in the Falklands, but we believe that Brazil will initially have to import night sights. [redacted]

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China

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China

China has designed and produced tanks similar to Soviet tanks, which it calls Type 59 and Type 69. The Type 59 tank—a Chinese copy of the Soviet T-54 tank—is in China's ground forces and has been exported to its principal client states. The newer Type 69 tanks have probably entered production for the Chinese ground forces, and a variant, the Type 69 Model 2, is exported. [redacted]

Chinese tank design, including the design of fire-control systems, has mimicked Soviet tank design. China did not have direct access to Soviet tank designs after the T-54. But the Type 69 tank may incorporate some features of the T-62 because in 1969 China captured at least one T-62 in the Ussuri River battles with the Soviets. [redacted]

We do not know whether to expect a new Chinese tank based on the Soviet T-72 design. T-72s are in Soviet forces in Mongolia and in India. China's army acknowledges that it may have to counter T-72s in future battles, but it may decide to counter them with weapons other than tanks (for example, infantry-carried ATGMs). We do not know whether the Chinese have gained access to the design of the Soviet T-72 tank. Chinese tank designers have asked US attaches about the composition of T-72 armor. [redacted]

Type 59

The fire-control devices for the Type 59 are similar to those used on T-54s. The model evolution of the Type 59 paralleled that of the T-54. Like the early T-54s, Type 59 tanks of the 1950s and 1960s had 100-mm rifled guns without bore evacuators, gun-drive stabilizers, or night-vision devices. Type 59s of the 1960s and 1970s had guns with bore evacuators behind their muzzles—similar to the D-10TG guns on T-54As. [redacted]

The Type 59 fire-control system basically consists of a coaxial telescope and the gun drive. The coaxial telescope is rigidly linked to the gun and contains

Table 1**Chinese Type 59 and Type 69 Weapons and Fire-Control Systems**

| | Type 59 | Type 69 Model 1 | Type 69 Model 2 |
|--------------------|---|---|--|
| Main gun | 100-mm rifled gun | Possibly 105 mm, probably smoothbore gun | 100-mm rifled gun |
| Gunnery devices | Coaxial telescope Externally mounted laser rangefinder White/IR searchlight | Coaxial telescope Possible laser rangefinder White/IR searchlight | Coaxial telescope Other devices unknown |
| Gun drive | Motorized with stabilized gun elevation | Possibly stabilized gun elevation and turret traverse | Unknown |
| Commander's sights | Binocular periscope with stadiametric rangefinder | Unknown | Unknown |
| Other weapons | 7.62-mm coaxial machinegun 7.62-mm bow machinegun 12.7-mm AA machinegun | 7.62-mm coaxial machinegun 12.7-mm AA machinegun | Probably same as Type 69 Model 1 |

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aiming reticles. The gunner aims by elevating the gun until the estimated range mark is on the target image, and then he fires the gun. [redacted]

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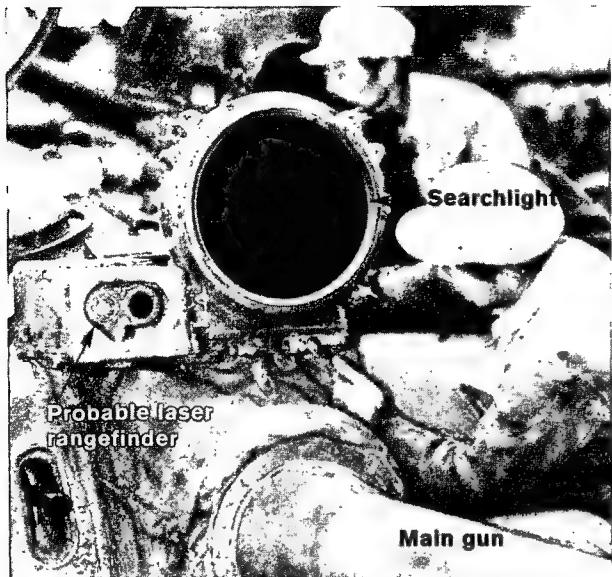


Figure 1. Chinese Type 59 tank with searchlight and probable laser rangefinder.

Users of the Type 59 have expressed interest in increasing its night-vision capabilities. Photographs in military journals in the early 1980s show Type 59s being built in an unspecified plant (almost certainly the Baotou armored vehicle plant). The tanks have infrared searchlights mounted on top of the main guns. The Chinese searchlights are similar to Soviet, tungsten-bulb, white/IR searchlights. The searchlights are probably linked to follow the guns, indicating a night-firing capability.

The photograph of the searchlight on a Type 59 in figure 1 shows what is probably a laser rangefinder of unknown type externally bolted to the starboard side of the searchlight. The device looks like laser rangefinders on some other armored vehicles, such as the US M551 Sheridan armored reconnaissance vehicle. The Chinese have captioned photographs of the devices as laser rangefinders, but we do not know if they are for battle or training.

We do not know what night sights are currently used in Type 59 tanks. The Chinese practice of mimicking Soviet designs and the Soviet-style searchlights seen on Type 59s imply that the Type 59s have Soviet-style active-IR, image-converting night sights.

Weapons trade publications state that China has probably bought passive night-vision sights for Type 59 tanks from the British MEL equipment company. We have no details on this purchase, but MEL does advertise passive night-vision periscopes specifically designed for Type 59 tanks. The MEL designators for the periscopes are the DC-1024 gunner's sights, DC-1026 commander's sights, and DC-1028 driver's sights. All of the sights use image intensifiers, and the gunner's sight can be linked with the gun for night firing.

An open British publication stated that in 1981 China acquired a thermal imager, the IR-18, offered by the British firm Barr and Stroud, probably for testing on a Type 59 tank.

Pakistan is trying to acquire US night sights for the Type 59 tanks it has imported. A tank night-firing suit made by the US firm Joanel was demonstrated to a Pakistani delegation visiting Fort Knox in 1981.

Type 69

The Type 69 tank is probably entering production for the Chinese ground forces. Its fire-control system probably works similarly to that of the Type 59, but it may have some new features such as stabilization of the gun drive for both traverse and elevation.

The Type 69 was confirmed in a photographic display at the Dalian Army Academy in 1981.

US and foreign attaches have reported that the Type 69 has a 105-mm gun. Photographs at the Dalian display lead US military attaches to conclude that the gun has a smoothbore. The photographs show ammunition that includes APFSDS rounds typically associated with smoothbore guns. The new guns have longer bore evacuators than the Type 59 guns.

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The Type 59 and 69 fire-control systems probably work similarly; that is, the Type 69 gunner aims the gun by looking through a coaxial telescope and operating the gun drive. This is based on our assessment that the Type 69 evolved from the Type 59, and the similarity in the sight heads on the two tanks. We believe that laser rangefinders of unknown type may be used to display ranges to the gunner, who then finds the appropriate range mark inside the coaxial telescope. The Type 69 laser rangefinder probably does not automatically feed range signals into a mechanized or computerized fire-control system.

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On the basis of trends in the tank programs of other nations, US projections of characteristics of the Type 69 include an "improved" fire-control system, including a laser rangefinder and a gun drive stabilized for traverse and elevation. The new guns and ammunition for the Type 69 indicate that its fire-control system differs from that of the Type 59. If the guns for the Type 69 have longer range capabilities than those for the Type 59, an accurate rangefinding capability, such as that offered by a laser rangefinder, probably would be needed.

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Type 69 Model 2

The export version of the Type 69 tank has a 100-mm rifled gun. Exported Type 69s may not have laser rangefinders and stabilized gun drives.

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France

France

The French firm GIAT designed the AMX-30, AMX-32, and AMX-40 tanks. France is upgrading its AMX-30s and will designate them AMX-30B2s; the upgrade includes major fire-control retrofits. The AMX-32 is intended for export, but it has not been popular. GIAT is developing the AMX-40 to replace the AMX-32 and is conceptualizing a tank to replace the AMX-30B2 in the 1990s. Only the AMX-30 and AMX-32 series of tanks are discussed here. [redacted]

AMX-30

The AMX-30 design grew out of an aborted Franco-German tank project of the 1950s. (The German result was the Leopard I.) Production of the AMX-30 began in 1966 and about 1,000 have been built for France. Spain has imported and coproduced between 225 and 435 AMX-30s for its armed forces. [redacted]

The French intended to test a missile-firing AMX-30, fitted with 142-mm ACRA ATGMs in the early 1970s, but the tests were canceled in 1973. [redacted]

The French Army AMX-30s remained unchanged until the late 1970s. By then, French firms had developed a variety of new tank sights, including many with laser rangefinders, passive image intensifiers, and LLLTVs and were beginning to develop thermal-imaging sights. The new sights are offered in several combinations, such as the COTAC (Conduite de Tir Automatique) and COSTAC (Conduite de Tir Stabilisee Automatique pour Char) families of fire-control equipment. By June 1979 the French Army had ordered the AMX-30B2 version with a new fire-control system based on the COTAC M581 fire-control devices. The COTAC system is described in the AMX-30B2 section. The COSTAC system has not been bought yet but may be ordered by AMX-32 customers; it is described at the end of the French tank section. [redacted]

Most exported AMX-30 tanks have the same weapons and fire-control systems as the AMX-30s in the French Army. [redacted]

The AMX-30 has a 105-mm gun of French design, unlike the NATO tanks produced at the same time as the AMX-30 (Leopard I, Chieftain, and M60), which

have the 105-mm British-designed L7 gun. The barrel of the main gun is 56 calibers long and is covered by a magnesium-alloy thermal sleeve. The gun has no muzzle brake or external bore evacuator; a compressed-air evacuator in the turret keeps combustion gases out of the turret. The breech has a vertically sliding wedge breechblock. The gun can be elevated to 20 degrees and lowered to -8 degrees. It can fire French or NATO ammunition at about 8 rounds per minute. [redacted]

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The coaxial weapon left of the main gun was initially a Browning 12.7-mm M2-HB machinegun. These machineguns may still be on some older exported AMX-30s. The coaxial machineguns were replaced early in AMX-30 production by French gas-operated, 20-mm M693 Model F2 automatic cannons. The M693 cannon traverses with the main gun. It can be elevated with the main gun to 20 degrees or independently of the main gun to 40 degrees and can fire up to 740 rounds per minute. High-explosive incendiary (HEI) and AP rounds are usually loaded into its dual feed mechanism, each feed holding one type; either feed can be selected for firing. Either the commander or gunner can fire the cannon when it is linked to the main gun elevation. [redacted]

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The commander acquires targets from within the TOP-7 rotating cupola. The cupola can counterrotate, enabling the commander to keep an acquired target in sight as the turret traverses toward the target. The cupola has 10 fixed vision blocks around its sides and an M270 periscopic head on top. The image from the M270 mirror enters an M267 day sight or OB-23-A night sight. The commander interchanges the sights. The night sight requires a near-infrared light source, supplied by a PH-9-A white/IR spotlight on the cupola. A 7.62-mm F1 machinegun is on the cupola and is fired from within the cupola by using the sights and spotlight. A servomechanism can be engaged to link the M270 mirror elevation to the 20-mm cannon, enabling the commander to aim the cannon independently of the main gun. [redacted]

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Table 2
AMX-30 Weapons and Fire-Control Systems

| | French Army AMX-30 | AMX-30B2 |
|---------------------|--|---|
| Main gun | 105-mm CN-105-F1 rifled gun | 105-mm CN-105-F1 rifled gun |
| Coaxial weapon | 20-mm M693 Model F2 coaxial automatic cannon | 20-mm M693 Model F2 coaxial automatic cannon |
| Gunnery devices | M271 coaxial telescope OB-17A or OB-47 night periscopes PH-8-B white/IR searchlight | COTAC M581 system: M544 coaxial telescope M550 Nd:YAG laser rangefinder M579 electronic controller M421 deviation computer DIVT-13 LLLTV system: video camera RR-107C monitor PH-8-B white/IR searchlight |
| Commander's devices | TOP-7 rotating cupola M267 day sight and OB-23A night sight in M270 periscopic mount M208 coincidence rangefinder PH-9-A white/IR spotlight | TOP-7 rotating cupola M496 day periscope TJN-223 image intensifier RR-107C monitor from DIVT-13 LLLTV system PH-9-A white/IR spotlight |
| Gun drive | CH27-1S nonstabilized electrohydraulic system | CH27-1S nonstabilized electrohydraulic system modified for COTAC interface |
| Other weapons | 7.62-mm F1 AA machinegun Four grenade launchers | 7.62-mm F1 AA machinegun Four grenade launchers |

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The commander is responsible for rangefinding and uses the Sopelem M208 coincidence-rangefinding sight mounted across the turret. The M208 is designed to measure ranges from 600 to 3,500 meters.

The AMX-30 cannot fire on the move. None of the sights are stabilized. A model CH27-1S electrohydraulic system built by the French firm SAMM drives the turret traverse and gun elevation but does not stabilize the gun.

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The gunner aims through a coaxial-sight mount, right of the gun, with either an M271 day sight or OB-17-A night sight. For night sighting, the target is illuminated with near-infrared light provided by a Sopelem PH-8-B searchlight mounted left of the 20-mm cannon. The French may have replaced the OB-17-A on some AMX-30s with the newer OB-47 periscopic night sight—a passive image intensifier.

SAMM once tested stabilized versions of the CH27 gun drive in an AMX-30 and Swiss Pz61 tank, but they were never adopted.

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Some AMX-30 tanks in the French Army have been fitted with RAPACE battlefield surveillance radars, which do not direct fire from the tank guns. We do not know whether the RAPACE radar provides target acquisition for individual tanks or conventional battlefield surveillance for armored units. [redacted]

Exported AMX-30 Tanks. Spanish-produced AMX-30s have the French AMX-30 fire-control systems, but they have 7.62-mm MG42/59 machineguns on their cupolas instead of 12.7-mm machineguns. [redacted]

Weapons trade publications have reported that the Sopelem OB-47 gunner's night sight is on exported AMX-30s in an unspecified foreign country, where it is used with a Sopelem M427-02 Nd:YAG or Nd:glass laser rangefinder. [redacted]

France offers an AMX-30 variant with a simplified fire-control system, but we do not know if any have been ordered. The simplified system has no night sights, an S470 cupola with a 12.7-mm machinegun instead of the TOP-7 with the 7.62-mm gun, and a 7.62-mm coaxial machinegun instead of the 20-mm coaxial cannon. [redacted]

France offers an AMX-30S ("Sahara" version) of the AMX-30 tailored for Middle Eastern desert conditions with engine, transmission, and track modifications. Saudi Arabia and Qatar have purchased these tanks. [redacted]

The AMX-30S has the same fire-control system as the French Army AMX-30, with the exception that some AMX-30S tanks have different commander's sights. At least one customer (unspecified by France) in the Middle East has AMX-30S tanks with Sopelem M409 sights on the cupola rather than M270 sights. The M409 is a combined day and night sight with a CILAS Company Nd:glass or Nd:YAG laser rangefinder. The M409 enables the commander to range from the cupola, without traversing the turret toward the target. We do not know whether the M409 sights were installed as original equipment or retrofitted after the tanks were shipped. The M409 can measure ranges between 400 and 10,000 meters. [redacted]

AMX-30B2

The fire-control system of the AMX-30B2 is very different from earlier AMX-30 systems (see figure 2). It has different commander's sights, COTAC gunnery sights, and an LLLTV system. The COTAC sights are a series of electronically controlled fire-control devices marketed by GIAT. The AMX-30B2 gun drive is not stabilized. [redacted]

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All of the AMX-30B2 armament is specified in weapons trade publications to be the same as the AMX-30 armament. The main gun on the AMX-30B2, however, may have been modified to fire the new French Fleche APFSDS rounds and NATO 105-mm APFSDS rounds (for example, the US M735). APFSDS firing could shorten the barrel life of the original gun on the AMX-30s because it may not have been designed for APFSDS rounds. [redacted]

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The AMX-30B2 commander's primary sights are the M496 periscope and probably the TJN-223 passive night sight. The sights are in front of the cupola. The M496 can be mechanically linked to the main gun and coaxial cannon to aim both weapons, but it has no electronic links to the COTAC computing elements. [redacted]

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The gunnery devices are packaged into a gunsight designated the COTAC M581. The M581 contains an M544 coaxial telescope, M550 laser rangefinder, M579 electronic controller, M421 angle-computing module, and a two-axis gyroscope. The M421 module contains an electronically driven aiming reticle. [redacted]

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The M550 laser rangefinder contains an Nd:YAG laser and can measure ranges between 320 and 10,000 meters. The M550 is sold by CILAS under the trade name TCV-80. [redacted]

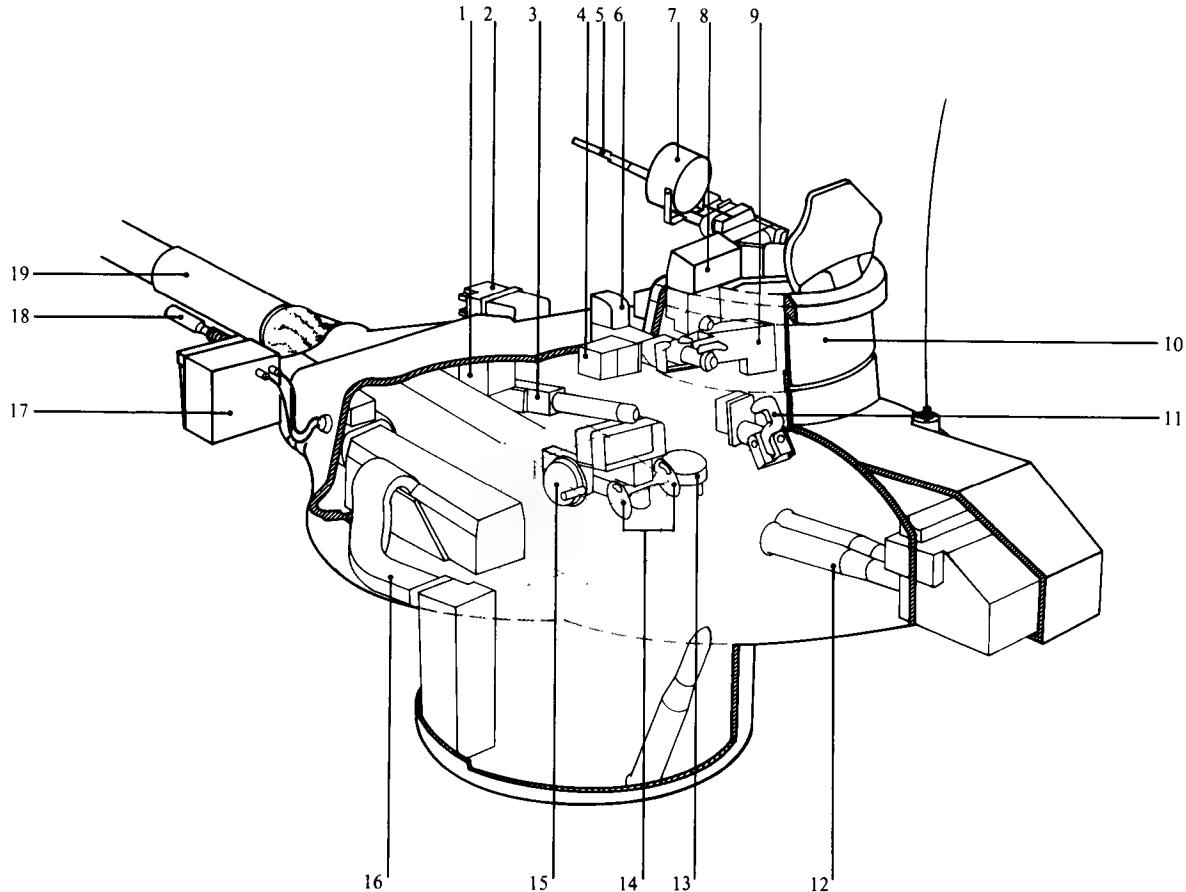
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In operation, the electronic elements of the M581 sight accept ballistic inputs from several sources, including the laser rangefinder, and generate super-elevation and traverse-offset angle signals. The angle

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Figure 2
French AMX-30B2 Fire-Control System



| | |
|------------------------------|--|
| 1. Gunner's LLLTV monitor | 11. Commander's control handle |
| 2. DIVT-13 LLLTV camera | 12. 105-mm ammunition |
| 3. COTAC M581 gunsight | 13. Traverse handwheel |
| 4. Commander's LLLTV monitor | 14. Gunner's control handles |
| 5. 7.62-mm machinegun | 15. Elevation handwheel |
| 6. M496 periscope | 16. Automatic cannon feed |
| 7. PH-9-A spotlight | 17. PH-8-B searchlight |
| 8. TJN-223 image intensifier | 18. M693 Model F2 20-mm automatic cannon |
| 9. Commander's console | 19. CN-105-F1 105-mm main gun |
| 10. TOP-7 cupola | |

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signals drive the M421 reticle to show the gunner where to aim. The gunner drives the gun until the reticle is centered in the sight and then fires. The range is displayed to the gunner for use if he chooses to aim manually. [redacted]

The ballistic inputs consist of target ranges, ammunition type, cant angle, turret-traverse and gun-elevation angles, ambient temperature and pressure, and windspeed. Ranges are automatically fed to the COTAC gunsight directly from the laser range-finder's electronic output or are entered manually by the commander from a console in the cupola. Ammunition selection causes electronically stored ballistic characteristics for the selected round to be fed into the M581 sight. The ammunition memory may be in the M581 gunsight but could be in the commander's panel because the commander selects ammunition. Cant angles are fed directly into the gunsight electronics from a cant sensor. Signals indicating the traverse and elevation angles enter the gunsight electronics from the gun-drive machinery. Ambient temperature, pressure, and windspeed are manually entered by the commander. [redacted]

The COTAC M581 gunsight can aim at moving targets. The two-axis gyroscope inside the sight provides traverse- and elevation-rate signals to the computer when the gun moves. The sight and gun are not stabilized by the gyroscope. [redacted]

The AMX-30B2 has a night-firing capability provided by a Thomson-CSF DIVT-13 LLLTV system. The DIVT-series systems are marketed as the CANASTA systems outside of France and have previously been designated TMV-560, TMV-561, and TMV-562. A DIVT-13 system on an AMX-30B2 consists of a CC8 TV camera mounted right of the main gun, a BC-458A control unit usually at the commander's side, and two RR-107C TV screens—one each for the commander and gunner. The CC8 camera can view dimly lit areas without a searchlight. The system displays a video reticle on the RR-107C screens. The video reticle is electronically positioned by the COTAC electronics. The screens also can display a stadiametric reticle for backup range estimation and aiming if the COTAC electronics fail. [redacted]

Although the LLLTV does not need a searchlight, many AMX-30B2 tanks still have the PH-8-B searchlight. All of the AMX-30B2s need the PH-9-A cupola spotlight to fire the cupola machinegun because the LLLTV system only points where the main gun is pointing. [redacted]

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The AMX-30B2 gun drive machinery is the CH27 electrohydraulic system. The system does not stabilize the gun, but it has gyroscopic tachometers (rate gyros) to provide angle-rate signals to the COTAC gunsight for ballistic computation. [redacted]

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AMX-32

France displayed the first prototype AMX-32, mounting a 105-mm gun, at the Satory show in 1979. The second prototype, with a 120-mm gun, was at the show in 1981. The AMX-32 was originally intended to be the AMX-30 follow-on in the French Army, but it has been offered solely for export. To our knowledge, France has not yet received any orders for the tank. [redacted]

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The AMX-32 tank is in a prototype stage of development. The most significant difference observed between the AMX-32 and AMX-30B2 fire-control systems is the addition of an M527 stabilized sight on the AMX-32 cupolas. We do not know whether the guns on the AMX-32 will be stabilized guns. [redacted]

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The first AMX-32 prototype had the 105-mm CN-105-F1 gun. The second had a new 120-mm smooth-bore gun developed by GIAT. The 120-mm gun is designed to fire German Rheinmetall 120-mm tank ammunition. [redacted]

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Both AMX-32 prototypes have COTAC M581 gunsights. The prototype shown in 1979 had the video camera for the DIVT-13 LLLTV system mounted to the right of the 105-mm gun, and a PH-8-B searchlight mounted to the left of the coaxial cannon. The prototype shown in 1981 had the DIVT-13 camera mounted to the left of the cannon, and no searchlight was used. [redacted]

25X1

Secret

The M527 cupola sight on the AMX-32 is made by GIAT and allows acquisition and designation while on the move. The M527 sights are made to traverse a full circle because AMX-32 cupolas do not rotate. The M527 contains its own elevation-stabilizing gyroscope. The sight is electronically linked to the COTAC M581 electronics and to the turret-traverse gyroscope in the gun drive. If the M527 sight is traversing to follow a moving target, a resolver in the sight receives signals from the turret-traverse and sight gyroscopes. The resolver adds the signals to obtain the azimuth of the M527 sight with respect to the turret and sends the azimuth to the COTAC gunsight, which shows the gunner where to traverse the turret. The AMX-32, however, probably must stop moving to fire. [redacted]

25X1

The commander can select one of two day channels and a night channel on the M527 sight. One day channel can be elevated from -12 to 24 degrees. The other day channel can be elevated from -20 to 40 degrees. The commander can use the channel with higher elevation when firing the 20-mm coaxial cannon. The night channel can be elevated from -8 to 24 degrees. [redacted]

25X1

The AMX-32 has an electrohydraulic gun drive system designated the ATS-GS-32. We do not know whether the gun drive will be stabilized. The gun drive has the traverse and elevation gyrotachometers used to feed angle-rate signals to the COTAC electronics, but we do not know if the gyrotachometers were designed as stabilizer references or simply used to smooth the gun drive's operation. We do not know if the gun drive has the necessary feedback circuits to provide gun stabilization. [redacted]

25X1

GIAT is developing a "stabilized COTAC" fire-control system designated COSTAC. The stabilized COTAC could be either the COTAC with a stabilized M527 sight or the COTAC with a stabilized gun. The COSTAC may be defined by whatever stabilized fire-control system is ultimately adopted for production-model AMX-32s or future French tanks. [redacted]

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Secret

Israel

Israel**Merkava**

The Merkava tank is the first tank designed and built by Israel. It was designed in the 1970s and officially unveiled in Jerusalem in 1978. Merkavas were in full production and entering service in the Israeli Army by 1981 and were in combat in the invasion of Lebanon in June 1982. [redacted]

Not all Merkava components are made in Israel. An Israeli publication states that 40 percent of the Merkava components are made in Israel, 24 percent are imported, and 36 percent are assembled in Israel using imported parts. Each Merkava tank is fully assembled at the Israeli Ordnance Factory at Tel a Shumer. [redacted]

US attaches have reported the existence of a project (Project 761) to standardize the fire-control procedures of all of the various Israeli Army tanks by retrofitting them with a standard computer-based system. The Israelis have approached US companies about terms of sale or licensed production of gyroscopes; resolvers; analog-to-digital converters; microprocessors; and large-capacity, random-access memories suitable for use in tank fire-control systems. These inquiries may be related to Project 761. [redacted]

The Israelis have announced two newer Merkava models—the Merkava II and III. The Merkava II is in development, and a prototype may be completed. Israeli press reports claim that the Merkava II may enter production in 1983. The Merkava III is in a design stage and is intended for production in the late 1980s. It may have a turbine engine. The new Merkava models are planned to have improved fire-control systems, armor protection, and suspensions. The Israelis have not specified the fire-control changes. [redacted]

The first Merkava gun drives may have been installed without stabilizing provisions; historically, the Israelis have preferred to fire from a halt. Stabilizing circuits have been retrofitted and adopted for new production. [redacted]

Table 3
Merkava I Weapons and
Fire-Control Systems

| | |
|--------------------|--|
| Main gun | 105-mm M64-L71A (Israeli-made M68) |
| Gunnery devices | Periscopic daylight sight with Nd:YAG laser rangefinder |
| | M13A1 digital electronic computer |
| | Optional night sight |
| | EOS xenon white/IR searchlight |
| Gun drive | S. H. L. electrohydraulic drive with optional or retrofitted stabilizing kit |
| Commander's sights | Panoramic periscope similar to German TRP-2A |
| | Separate passive night sight |
| Other weapons | 7.62-mm coaxial machinegun left of main gun |
| | 7.62-mm machinegun at commander's station |
| | Optional 7.62-mm machinegun at loader's station |
| | Optional possibly 12.7-mm coaxial machinegun above main gun |
| | 60-mm mortar carried on turret with 30 rounds |

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Merkava's 105-mm rifled gun is built by Israel Military Industries and is designated the M64-L71A. The gun is a version of the US M68 gun. (The M68, in turn, is a US adaptation of the British L7 gun.) A thermal sleeve is provided with most Merkava guns. The Israelis specify that their gun can fire 7 rounds per minute in the field; a trained crew once demonstrated a firing rate of 12 rounds per minute. [redacted]

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The Merkava machineguns are supplied by Israel Military Industries and are licensed copies of the 7.62-mm MAG58 machineguns made by the Belgian

25X1

firm Fabrique Nacional. One machinegun is mounted coaxially left of the main gun, and one or two more are mounted on top of the turret. Some published photographs of Merkavas show a larger machinegun, probably a copy of the Browning 12.7-mm M2-HB, mounted coaxially on top of the main gun mantlet. [redacted]

Merkava I tanks carry a 60-mm mortar on the turret roof, with up to 30 mortar rounds in external stowage areas. Currently, the crew must exit the tank to use the mortar. The Israelis are developing a version of the mortar that is loaded and fired from within the tank. [redacted]

The Merkava commander has a panoramic periscope probably identical to the TRP-2A commander's sight in West German Leopard I tanks. The external sight head resembles the Leopard I's, and published specifications are identical to those of the TRP-2A. The commander's sight is supplied by Israel Aircraft Industries. The Israeli sight is specified to have 4- to 20-power zoom magnification, a counterrotating link, and coupling to the gunner's sight. The counterrotating link keeps the sight pointed at an acquired target as the turret traverses toward the target. [redacted]

The Merkava gunner's sight is mounted in a channel cut into the right front of the turret. Steel ribs set across the channel protect the sight from ricochetting small arms rounds. An armored lid covers the sight when it is not in use. [redacted]

The gunner's sight is a daylight periscope containing an Nd:YAG laser rangefinder made by the Israeli firm El-Op and a computer-driven reticle. The exact designation and configuration of the sight in deployed Merkavas is unknown. Different international publications have described the sight as having zoom magnification to 12 power or as having two magnifications, unity and 8 power. The acronym SLS, mentioned by some Israelis, may refer to the sight, part of the sight, or an optional night sight. [redacted]

The Merkava computers are M13-series digital-electronic ballistic computers built by the Israeli firm Elbit. The Merkava fire-control system is often referred to as the Elbit system. The computer receives ranges from the laser rangefinder and several other ballistic inputs from other sensors. The computer then

calculates the superelevation and traverse-offset angles, including a moving-target lead angle in the traverse offset. The angle signals are applied to a ballistic drive that displaces the reticle in the gunner's sight. The reticle is probably linked by a servomechanism to the gun drive machinery, so that it shifts back to center as the gun approaches the correct azimuth and elevation. [redacted]

The superelevation signal is also sent to the hydraulic elevation part of the gun drive. This signal may be used to raise the gun automatically to firing elevation. [redacted]

The laser rangefinder, cant, and traverse-rate sensors automatically send signals to the computer. The traverse-rate sensor measures the turret traverse rate as the gunner follows a moving target. The computer also automatically receives feedback signals measuring the actual superelevation and offset angles of the reticle to ensure that these angles match the calculated angles. Ammunition choice can be entered into the computer by any of the turret crew from their control panels. The gunner can enter throwoff angles for each type of ammunition to compensate for the gun jumping up and to one side as it fires. He also can enter windspeed, charge temperature, gun-barrel droop, and air pressure. The range is displayed to the gunner for use in any manual aiming or range verification. A gun-wear estimate, based on the number of rounds that have been fired from the gun, is stored in the computer. [redacted]

Elbit has built a model of the Merkava computer-and-sensor subsystem with automatic sensors for all of the computer inputs. The company has claimed in advertisements that the automatic sensor model is being exported. [redacted]

Early Merkava tanks may have had a different computer that was similar to the cam-operated computers in early US M60s. In 1979 a US attache report on the early production models of Merkava described the computer as a ballistic computer taken directly from M60 supplies. M60 computers were designated

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SecretM13s by the United States. 25X1
25X1

The gunner's computer-control panel has a provision for aligning the sight and gun boresights. The alignment procedure may involve introducing an electronic bias in the computer to compensate for small sight misalignments, instead of a precise mechanical alignment. 

25X1

For night firing, all Merkava I tanks have a 1-kilowatt EOS xenon searchlight, probably a passive night sight to replace the commander's panoramic periscope, and possibly an optional gunner's night sight. The searchlight is permanently mounted at the turret rear in a spaced-armor recess. A reflector controlled by the commander opens over the searchlight and directs the searchlight beam; the searchlight itself is under armor. Early production Merkavas had no gunner's night sight, much to the dissatisfaction of the Israeli tankers. The Israelis probably require a gunner's night sight, but none have been identified. The Israelis also are interested in thermal-imaging sights for Merkavas. 

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The Merkava gun drive is probably a stabilized electrohydraulic drive designed by the US firm Cadillac Gage and made in Israel under license. Earlier Merkavas had nonstabilized gun drives by Cadillac Gage, called the S. H. L. in Israeli publications, but have probably been fitted with an add-on stabilization option. 

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The Merkava shown at the first official unveiling of the tank at the Independence Day show in Jerusalem in 1978 had a cylindrical fitting on the top center of the turret. The cylinder was not seen on other Merkavas. The cylinder is unidentified but superficially resembles the Leopard II commander's sight head. 

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Japan

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Japan

The Japanese Self-Defense Forces have Type 61 (prototype STA) and Type 74 (prototype STB) tanks built by Mitsubishi Heavy Industries. A new prototype, the STC, is being developed and probably will be called the Type 88.

The design of the Type 61 was influenced by that of the US M47 and M48 tanks. Type 61 production began in 1962 and is complete, with production lines now converted for the newer Type 74 tanks. About 560 Type 61 tanks were built, and none have been exported.

Production of the Type 74 tank began in 1975. At least 225 have been built, and we believe about 500 will be built. The propulsion system of the Type 74 includes an unusual variable hydropneumatic suspension that the driver or commander can use to raise, lower, or tilt the entire tank. The tank can be tilted forward, backward, or sideways. The Type 74s have not been exported.

Japanese inventiveness was evidenced in the Type 74 prototypes. The first Type 74 prototypes (STB-1 and STB-2) had autoloaders for their 105-mm guns. The autoloader project was abandoned by the time of the third STB prototype because of its complexity and high cost. The early STB prototypes had the top machinegun mounted on the rear of the turret; the gun was to be fired by remote control, but the scheme was dropped for production models because of its complexity.

Development of the STC prototype tank began in 1976, and we expect the first prototype to be finished in 1983. Series production is expected to start in the late 1980s. The Japanese have developed most of the technology for the STC. It will probably have 120-mm guns and multilayer steel/ceramic armor. STC fire-control details have not been specified because of the early stage of tank development.

Type 61

The Type 61 main gun is produced by Japan Steel Works. Its design and mounting in the turret are based on the 90-mm M41 gun and M87 gun mount used in US M48 tanks. The gun has a T-shaped

Table 4
Japanese Tank Weapons and
Fire-Control Systems

| | Type 61 | Type 74 | |
|---------------------|--|---|------|
| Main gun | 90-mm Type 61P rifled gun | 105-mm L7A3 rifled gun | 25X1 |
| Gunnery devices | Observation periscope Coaxial telescope No computer | J2 periscopic sight with active-IR night channel J1 coaxial telescope Analog-electronic computer linked to J2 and J3 sights | 25X1 |
| Commander's devices | Rotating cupola Observation periscope Cupola-mounted coincidence rangefinder | Fixed cupola J3 periscopic sight with ruby laser rangefinder and active-IR night channel | 25X1 |
| IR light source | Some retrofitted xenon white/IR searchlights | Xenon white/IR searchlights | 25X1 |
| Gun drive | Nonstabilized electro-hydraulic system | Stabilized all-electric system | 25X1 |
| Other weapons | .30-caliber M1919A4 coaxial machinegun .50-caliber M2-HB AA machinegun | 7.62-mm Type 74 coaxial machinegun 12.7-mm M2-HB AA machinegun | 25X1 |

muzzle brake and a bore evacuator behind the brake, but no thermal sleeve. The main gun fires APC and HE rounds.

The main gun is aimed with a 6-power coaxial telescope. The commander cannot aim the gun but must give target ranges to the gunner. The only other vision device for the gunner is a 4-power periscope over his position.

The commander sits under a rotating, domed cupola, similar to cupolas on early US M48s. The aft section of the cupola is the hatch. A Browning 12.7-mm M2-HB machinegun is on the forward part of the

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cupola, and a 7-power sighting periscope is forward of the machinegun mount. The cupola contains a 12-power coincidence rangefinder. It provides lower accuracy than would a rangefinder extending across the entire turret, but the commander can range in any direction without traversing the turret. [redacted]

Type 61 tanks have no night-vision devices. Some have searchlights mounted left of the main gun. [redacted]

The gun drives are electrohydraulic traverse and elevation mechanisms, which do not stabilize the gun. The commander can override the gunner's control of the turret drives. [redacted]

Type 74

The Type 74 tank has the British-designed 105-mm L7A3 main gun modified with a vertically sliding breechblock. A concentric recoil mechanism was designed and adopted by the Japanese to reduce the volume requirements for the turret. The gun fires up to 9 rounds per minute. [redacted]

The 7.62-mm coaxial weapon is designated the Type 74 Vehicle-Mounted machinegun. It is made by the Nihon Tokushya Kinzoka (Japan Special Metal) Company. The coaxial machinegun is left of the main gun and can be fired by the commander, gunner, or loader. It is cooled by a forced-air system that can also be used to cool the interior of the turret. A Browning 12.7-mm M2-HB antiaircraft machinegun is mounted between and forward of the cupola and loader's hatch. [redacted]

Both the commander and gunner can aim and fire the main gun. Normally, the commander operates a laser rangefinder that automatically sends the target range to a ballistic computer on the right turret wall. The computer generates superelevation and traverse-offset signals, corrected for cant, which through servomotors offset aiming reticles in the sights. The gunner, or the commander if necessary, uses a joystick to control the gun drive. The aiming reticles shift back to center as the gun approaches the correct position. The gun is ready to fire when the reticles are centered. [redacted]

The commander's sight, built by Nikon and designated the J3, contains the laser rangefinder. The J3 sight is mounted in a rotating perisopic mount; the Type

74 cupola is fixed. The sight has two fields: a unity-power field of 80 degrees for observation and an 8-power, 8-degree field for target engagement. [redacted]

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The laser rangefinder in the J3 sight contains a ruby laser and can range between 200 and 3,000 meters. The range accuracy is 10 meters. Either the commander or gunner can activate the laser. The computer panel has a range gate switch that must be set before laser rangefinding. The range gate rejects range readings from laser returns off objects closer than the target. The range gate can be set to reject readings of less than 300, 500, 1,000, 1,500, or 2,000 meters. The rangefinder circuitry consists of a hybrid integrated-circuit mix of analog signal processors and digital logic circuits. The laser rangefinder is built by Nippon Kogaku (Nippon Electric). [redacted]

25X1

The ballistic computer is an electronic analog computer built by Mitsubishi Electric. The commander manually enters ammunition selection, a gun-wear estimate probably based on the number of rounds fired, range estimates, and ammunition charge temperature. The computer calculates the superelevation and azimuth offset signals sent to the sights to aim the gun. The angles are static outputs; the traverse-offset angle is not a lead angle for moving targets but is corrected for cant angles. The computer automatically corrects for parallax between the gun and J3 sight as a function of range. We do not know the size or type of computer memory. [redacted]

25X1

The superelevation and traverse-offset angles are corrected for cant by the computer. We do not know if the commander enters cant angles after reading a cant sensor or a cant sensor automatically sends signals to the computer. The variable suspension of the Type 74 tank can be used to reduce the cant angle by tilting the tank in the uphill direction. [redacted]

25X1

The gunner's primary sight, designated the J2 perisopic sight, is made by Fuji—Photo Optical, which calls it the KK-1S sight. The J2 has two selectable fields: a unity-power, 28-degree observation field and an 8-power, 8-degree aiming field. The gunner's secondary sight is a J1 coaxial telescope mounted right of the main gun. [redacted]

25X1

The gunner's primary sight, designated the J2 perisopic sight, is made by Fuji—Photo Optical, which calls it the KK-1S sight. The J2 has two selectable fields: a unity-power, 28-degree observation field and an 8-power, 8-degree aiming field. The gunner's secondary sight is a J1 coaxial telescope mounted right of the main gun. [redacted]

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All of the sights—J1, J2, and J3—have aiming reticles mechanically linked to the main gun in elevation. The aiming reticles in the J2 and J3 are offset by servomotors driven by the computer output. The J1 coaxial telescope is not driven by the computer and is used only for manual aiming. [redacted]

The Type 74 sights all have selectable night-viewing channels, which contain IR-to-visible image converters. The converters require an active-IR light source to illuminate the target. A xenon white/IR search-light, mounted left of the main gun, provides illumination and can be filtered to provide near-IR illumination. [redacted]

The servodriven sights and laser rangefinder can be aligned from the computer panel. The computer does this by sending a correction signal to the reticle servomotors, which shift the reticles to line up with the line of sight of the laser rangefinder. [redacted]

The Type 74 gun drive machinery is electrically—driven, and the gun and turret are stabilized. Their sights are not self-stabilized but follow the gun. The commander can override the gunner's traverse control. [redacted]

The gun drive operates in three selectable modes: manual, stabilized, and power. The manual mode drives the gun by amplifying signals from the joysticks directly to the drive motors. The stabilized mode connects traverse-angle, elevation-angle, and angle-rate feedback circuits to the amplifiers. The amplifiers compare these with joystick commands to detect traverse and elevation errors and error rates. The amplifiers then send correction signals to the motors. We have little detailed information on the power mode. It possibly provides "fully automatic" gun aiming, meaning little or no manual intervention at the joysticks after initial positioning of the reticles near the target. Judging from a US block diagram of the Type 74 gun drive compiled from attache reports and brochures, the computer may send its superelevation and traverse-offset signals to the aiming-reticle servos and to the power amplifiers in the gun drive. The computer signals may be compared with feedback signals from the gun drive to generate correction signals to the motors. The motors may then drive the gun in a way that shifts the reticles back to center automatically. [redacted]

The gun drive technology is conventional, direct current (DC) control machinery. Much of the feedback signal-processing circuitry is in a box containing 34 electromechanical relays and 13 types of electronic analog circuits. The relays and circuitry form a logic network to connect the appropriate circuits as one of the three modes is selected. The network also provides safety interlocks. The final power amplifiers before the drive motors are liquid-cooled, dual-channel servoamplifiers. Traverse and traverse-rate feedback signals are generated by a traverse gyrotachometer, differential synchrotransformer, and resolver. Elevation and elevation-rate signals are generated by an elevation gyrotachometer and two differential synchrotransformers. The gain of the elevation synchrotransformers is apparently controlled by a transformer that receives computer-generated angles in the power mode. [redacted]

The gun drive can lower the gun to -6.5 degrees and raise it to 9.5 degrees. If the variable suspension is used to tilt the tank forward or backward, the gun can be elevated from -12.5 degrees to 15 degrees. [redacted]

Type 88

The Type 88 tank program is in a prototype stage. Characteristics of the tank will not be standardized until 1988. The main gun will be a 120-mm smooth-bore gun, possibly of Japanese design. The first prototype gun was finished in 1979. The gun will fire Japanese ammunition—APFSDS rounds developed by Daikin Industries and HEAT-FS rounds developed by Komatsu Machinery. The coaxial and top weapons will probably be the same as those on the Type 74s. [redacted]

Western speculation based on Japanese technological capabilities and tank fire-control trends in the United States and Europe lead to high expectations for the Type 88 fire-control system: self-stabilized sights with passive night channels, thermal-imaging channels, and Nd:YAG or carbon dioxide laser rangefinders; LLLTV sensors with video processing; integrated electronic computer and control circuitry; distributed

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microprocessors in each sensor; and an all-digital fire-control system. Lessons learned during development of the STB prototypes may enable the Japanese to provide an autoloader and remote-controlled machineguns for the Type 88. Device designations, characteristics, system architecture, and performance, however, are presently undefined.

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South Africa

Secret**South Africa****Olifant**

South Africa is producing its own tank, the Olifant (Elephant). Externally, the Olifant is a copy of the British Centurion Mark 5 and 7 tanks. [redacted]

25X1

We do not know any technical details about the Olifant weapons and fire-control systems. We assume that the main guns are South African copies of the British 105-mm L7 guns. [redacted]

25X1

The Israeli firm Elbit claims in its advertisements that a version of its tank fire-control system developed for Merkava has been exported but does not disclose to which country. [redacted]

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[redacted] the Olifant fire-control system may be imported from Israel. [redacted]

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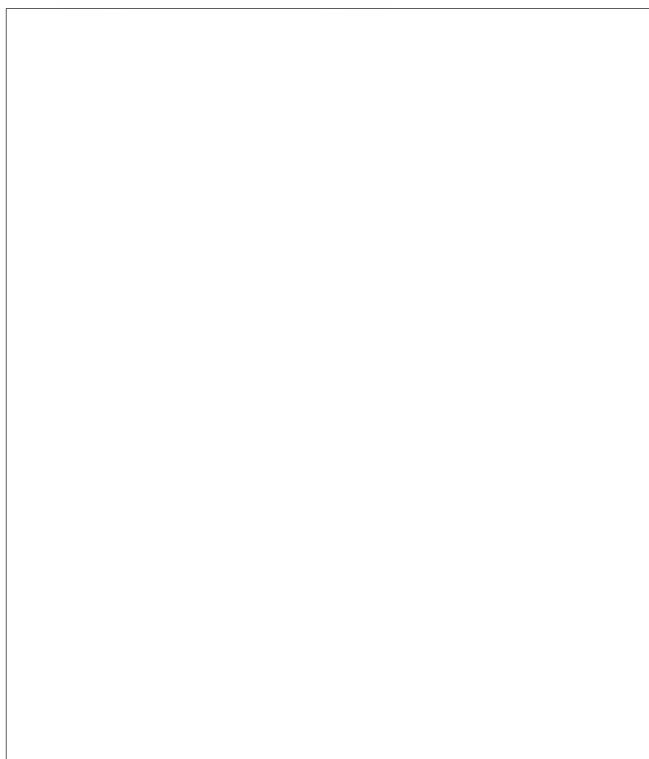
South Korea

ROKIT Project

South Korea has begun a program called the Republic of Korea Indigenous Tank (ROKIT) project. We do not know the exact status of the project. The US firm General Dynamics has been working on a ROKIT design and has built two prototypes. [redacted]

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Soviet Union

Soviet Union

Since World War II, the Soviets have built T-54, T-55, T-62, T-64, T-72, and T-80 tanks and their production variants. The T-54s, T-55s, and T-62s have similar fire-control systems. They are in service in the Warsaw Pact nations and have been exported to many other countries. The newer T-64s, T-72s, and T-80s use a variety of more advanced and integrated fire-control systems. [redacted]

T-54, T-55, and T-62

T-54s entered service in 1947. China, Czechoslovakia, Poland, and the Soviet Union produced T-54s once they were standardized. Three more standard models recognized by NATO—the T-54A, T-54B, and T-54C—appeared between 1955 and 1960. Production of T-54s ended in the mid-1960s, except in China, which is still building a copy of the T-54B called the Type 59. [redacted]

T-55s were first produced in 1958. The Soviets, Czechoslovaks, and Poles built T-55s from the 1960s to the late 1970s. One new NATO-recognized model, the T-55A, was first seen in the May Day Parade in 1963. Romania has modified many of its T-55s, calling the modified tanks the TR-77 (NATO designator M1978) and TR-800 tanks. [redacted]

T-54s and T-55s almost look alike. The T-54, however, has a turret-ventilation dome. Other major external differences among the original T-54 and T-55 production models are the placements of gun-bore evacuators, night-vision devices, and turret cupolas. The standard T-54 had no bore evacuator. Successive T-54 models (T-54A, T-54B, T-54C) and T-55s have bore evacuators behind the gun muzzles. T-54s and T-54As were originally supplied without night-vision devices. T-54Bs, T-54Cs, and T-55s came with night-vision devices. T-54s through the T-54B have commander's and loader's cupolas. T-54Cs and T-55s only have commander's cupolas. [redacted]

Earlier T-54s had DShK 12.7-mm AA machineguns mounted on the loader's cupolas. Because it does not have a loader's cupola, the T-54C usually has no AA machinegun. [redacted]

The bore evacuators, night-vision devices, and AA machineguns are no longer reliable recognition features. The Soviets have retrofitted new guns with bore evacuators and night-vision devices to older T-54s. Optional AA machinegun mounts are available for commander's cupolas. [redacted]

25X1

T-62s were first seen in 1961. T-62s have 115-mm guns with bore evacuators halfway down their barrels. T-62s have the same night-vision devices as those on T-54s and T-55s. Loader's hatches on early T-62s fit into a rounded turret; the turret on the one new model, T-62A, is raised and flattened around the loader's hatch. The flat area allows mounting of a DShK 12.7-mm AA machinegun. [redacted]

25X1

The Soviets were the only confirmed producers of the T-62 until 1978, when North Korea probably began producing T-62s. We estimate that several hundred T-62s are deployed in the North Korean Army. [redacted]

25X1

Original-Production T-54, T-55, and T-62 Weapons and Fire-Control Systems. T-54, T-55, and T-62 fire-control systems work similarly in principle. The commanders acquire and designate targets and estimate ranges, with or without binocular sights in their cupolas. Gunners aim through coaxial telescopes, raise the guns with their gun-drive control handles, and fire. [redacted]

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T-54s and T-55s have 100-mm rifled main guns with designators in the D-10T series. The designator assigned is correlated to the type of gun drive as follows:

- Early T-54s had manually cranked gear trains and were equipped with the D-10T gun.
- The T-54A had an electrohydraulically powered elevation drive with elevation-stabilizing circuits and manually cranked traverse gears and was equipped with the D-10TG gun.
- The T-54B and its successors have two-plane, stabilized gun drives with powered machinery and stabilizing circuits for both traverse and elevation. The gun is designated D-10T2S. [redacted]

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Table 5
Soviet Original-Production T-54, T-55, and T-62
Weapons and Fire-Control Systems

| | T-54 | T-54A | T-54B | T-54C | T-55 | T-55A | T-62 | T-62A |
|---------------------|---|---|---|---|---|---|---|---|
| Main gun | 100-mm D-10T rifled gun | 100-mm D-10TG rifled gun | 100-mm D-10T2S rifled gun | 100-mm D-10T2S rifled gun | 100-mm D-10T2S rifled gun | 100-mm D-10T2S rifled gun | 115-mm U5-TS smoothbore gun | 115-mm U5-TS smoothbore gun |
| Gunnery devices | TSh2-22 coaxial telescope | TSh2A-22 coaxial telescope | TSh2B-22 coaxial telescope | TSh2B-22A or TSh2B-22B coaxial telescope | TSh2B-22A or TSh2B-22B coaxial telescope | TSh2B-22A or TSh2B-22B coaxial telescope | TSh2B-41U coaxial telescope | TSh2B-41U coaxial telescope |
| | No night-vision devices | TPN1-22-11 or TPN1-41-11 active-IR night sights | TPN1-22-11 or TPN1-41-11 active-IR night sights | TPN1-22-11 or TPN1-41-11 active-IR night sights | TPN1-22-11 or TPN1-41-11 active-IR night sights | TPN1-22-11 or TPN1-41-11 active-IR night sights | TPN1-41-11 active-IR night sight | TPN1-41-11 active-IR night sight |
| | | L-2G tungsten white/IR searchlight | L-2G tungsten white/IR searchlight | L-2G tungsten white/IR searchlight | L-2G tungsten white/IR searchlight | L-2G tungsten white/IR searchlight | L-2G tungsten white/IR searchlight | L-2G tungsten white/IR searchlight |
| Commander's devices | TPK-1 periscope | TKN-1 day/ night periscope with active-IR night channel | TKN-1 day/ night periscope with active-IR night channel | TKN-1 day/ night periscope with active-IR night channel | TKN-1 day/ night periscope with active-IR night channel | TKN-3 day/ night periscope with active-IR night channel | TKN-3 day/ night periscope with active-IR night channel | TKN-3 day/ night periscope with active-IR night channel |
| | No spotlight | OU-3GK white/IR spotlight mounted on cupola | OU-3GK white/IR spotlight mounted on cupola | OU-3GK white/IR spotlight mounted on cupola | OU-3GK white/IR spotlight mounted on cupola | OU-3GK white/IR spotlight mounted on cupola | OU-3GK white/IR spotlight mounted on cupola | OU-3GK white/IR spotlight mounted on cupola |
| Gun drives | Nonstabilized manual gears | Stabi- lized power eleva- tion, nonsta- bilized manual traverse | STP-2 fully stabilized electrohy- draulic system | STP-2 fully stabilized electrohy- draulic system | STP-2 fully stabilized electrohy- draulic system | STP-2 fully stabilized electrohy- draulic system | Fully stabilized electrohydraulic system | Fully stabilized electrohydraulic system |
| Other weapons | 7.62-mm SGMT coaxial and bow machine- guns | 7.62-mm SGMT coaxial and bow machine- guns | 7.62-mm SGMT coaxial and bow machineguns | 7.62-mm SGMT coaxial and bow machineguns | 7.62-mm SGMT coaxial and bow machineguns | 7.62-mm PKT coaxial machinegun | 7.62-mm PKT coaxial machinegun | 7.62-mm PKT coaxial machinegun |
| | No AA machine- gun | 12.7-mm DShK AA machine- gun | Optional 12.7-mm DShK | Optional 12.7-mm DShK | Optional 12.7-mm DShK | Optional 12.7-mm DShK | No AA machinegun | 12.7-mm DShK AA machinegun |

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T-54 and T-55 commander's cupolas rotate. Binocular sights are mounted on the cupolas, whose sides are lined with glass blocks to aid vision. T-55A cupolas were the first Soviet cupolas designed to counterrotate. This capability has been provided on all Soviet tanks since the T-55A. On early T-54 and T-54A tanks, commanders had a daytime-only optical sight designated the TPK-1. On the T-54B and successive T-54s and T-55s, the TPK-1 was replaced by a day-and-night sight, designated the TKN-1, and a white/IR cupola spotlight designated the OU-3GK. The OU-3GK uses a tungsten light bulb that emits a mixture of visible and near-infrared light. The night channel of the TKN-1 contains a high-voltage, image-converter tube to convert near-IR light rays to visible images in the eyepiece. For night sighting, the targets must be illuminated by near-IR light, which is provided by filtering the visible light out of the visible-infrared light emitted from the OU-3GK spotlight. []

T-62 commanders acquire targets with sights designated the TKN-3. The TKN-3 is a day-and-night binocular sight that works similarly to the TKN-1. The T-62 has an OU-3GK white/IR spotlight on the cupola to provide near-IR light for the night channel. The most significant differences between the TKN-1 and TKN-3 sights are their relative sensitivity and power-supply housings. The TKN-3 is more sensitive than the TKN-1. The high-voltage power supply for the TKN-3 is contained within the sight housings, but the TKN-1's is housed separately. []

The cupola sights on T-54s and T-62s contain stadiametric scales to aid the commander in range estimation. []

T-54, T-55, and T-62 coaxial telescopes contain aiming scales marked for different types of ammunition. The designators selected for the telescopes depend, in part, on the aiming reticles they contain. []

Gunners on the night-capable T-54s, T-55s, and T-62s aim with a TPN1-series night sight and a large L-2-series white/IR searchlight mounted on the front of the turrets. The night sight and searchlight work like the commander's sight and spotlight, except that the searchlight uses a brighter tungsten bulb. The gunner's night sight is a monocular periscope. The

sight mirror and searchlight are linked to the main gun in elevation, so that the searchlight and night sight always look in the direction the gun is pointing. The night sight has aiming scales, but they are not as finely graduated as the scales for day sighting. The Soviet night-vision devices are designed for use within 1 kilometer (km) of a target. []

25X1

T-54, T-55, and T-62 Fire-Control Modifications. Since 1978 we have seen some Polish and Soviet T-54s, T-55s, and T-62s with boxes mounted over their main guns. The boxes may contain laser rangefinders or laser training devices because they are aimed in the same direction as the guns and have an optical aperture on the front. []

25X1

Tank guns and some fire-control devices have to be replaced periodically. Countries with close ties to the Warsaw Pact probably receive replacement parts that are the same as those originally supplied with their tanks. Fire-control systems probably would not be modified unless new types of ammunition were issued. For example, T-55s used in the 1967 Arab-Israeli war did not have HEAT scales on their coaxial telescope reticles because the Soviets did not issue HEAT rounds with the tanks. For accurate aiming of HEAT rounds, the coaxial telescopes would require new reticles. []

25X1

Some countries with T-54s, T-55s, and T-62s are turning to Western and Third World gun and fire-control suppliers because they do not want to depend on the Warsaw Pact nations. Some of the Western devices provide capabilities, such as laser rangefinding and passive night vision, that the Soviets have not freely offered to export customers. []

25X1

25X1

We expect more Western offerings of laser rangefinders and passive night sights for exported T-54s, T-55s, and T-62s. The armor openings on these tanks are not big enough for conventional coincidence or stereoscopic rangefinders without armor modifications. Nevertheless, many available laser rangefinders and passive night sights can be made to fit inside the existing openings for the coaxial telescopes, gunner's night sights, or commander's sights. []

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Many Yugoslavian T-54s and T-55s have commander's sights designated the TLMD-2. The sights are made by the Yugoslavian firm Iskra and contain neodymium:YAG laser rangefinders made by the Norwegian firm L. M. Ericsson. [redacted]

Iraq is importing night-vision devices for T-55s and T-62s [redacted]

Egyptian T-54s, T-55s, and T-62s have been fitted with white/IR searchlights made by the German firm AEG-Telefunken. Egyptian T-62s also have been fitted with the Yugoslavian Iskra commander's sights. [redacted]

India and Israel have mounted 105-mm guns that are compatible with NATO ammunition in some of their T-54s and T-55s. The Indians use the British L7 gun and the Israelis use copies of the US M68 gun. We do not know the extent of the changes to the fire-control systems. If the tanks retain their Soviet fire-control systems, they would at least require adjustments to the gun drive and new aiming reticles to accommodate the new guns and ammunition. [redacted]

The Israeli-modified T-54s and T-55s are often called TI-67 tanks and are the most extensively modified T-54s and T-55s. Israel captured hundreds of the tanks in the 1967 Arab-Israeli war and the 1973 Middle East war. The Israelis also captured large numbers of T-62s in the 1973 war. They have not changed the 115-mm guns even though it is difficult to obtain 115-mm ammunition. [redacted]

Israel captured more T-54s, T-55s, and T-62s in the fighting in Lebanon in 1982 but has not refurbished or modified them yet. [redacted]

The Israelis may refit their T-54, T-55, and T-62 tanks with a computer-driven aiming sight [redacted]

[redacted] Israel may decide, however, that funds for refitting the old Soviet tanks would be better spent on the development of a new tank. [redacted]

Proposals to refit Israeli T-54s and T-55s with the US Cadillac Gage stabilized gun-drives used on M60A1 tanks have not materialized. [redacted]

T-64, T-72, T-80, and Newer Soviet Tanks

The Soviet tanks deployed after the T-62 are divided by the Intelligence Community into three groups based on visible features not related to fire-control, such as their characteristic roadwheels, engine decks, and arrangement of turret equipment. The three groups are the T-64 group, T-72 group, and a new group identified in the East German Letzlinger Heide training area in April 1983. We do not know the exact identity of the T-80. All of these tanks have auto-loaders, and all but the early T-64s have 125-mm smoothbore guns. [redacted]

We can describe the fire-control systems of these tanks without exactly identifying each model. The fire-control systems can be independently divided, depending on the point of interest, into those with or without coincidence rangefinders (see figure 3), or those with or without ATGM-guidance subsystems. The descriptions in this section are structured along the rangefinder characteristics. We have a much better understanding of the operation of the fire-control systems based on coincidence rangefinders—the T-64A and T-72—than those without. [redacted]

The T-64 group consists of the early T-64 tank and later T-64A and T-64B tanks. The early T-64s entered production between 1968 and 1970, had 115-mm guns, and were discontinued at an early production stage. The Soviets then adopted the 125-mm smoothbore guns. T-64As have coincidence rangefinders and T-64Bs do not. The T-64B gun can fire both conventional rounds and ATGMs. All T-64s are deployed only in Soviet Forces. [redacted]

The T-72 group consists of the standard T-72 and several T-72 variants. Standard T-72s have the same coincidence rangefinders as the T-64As, whereas observed T-72 variants do not have coincidence rangefinders. [redacted]

T-72s are deployed in Soviet Forces and other Warsaw Pact armies and have been exported to Algeria, India, Iraq, Libya, North Yemen, and Syria. [redacted]

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Figure 3. Fire-control differences in Soviet T-72 series tanks.

T-72.



T-72 variant.



[redacted] a T-72 variant shown in the Moscow parade in 1982 as the T-80. This identification does not resolve our all-source data on the T-80. The tanks had thicker frontal armor than T-72s and did not have coincidence rangefinders. [redacted] there are three versions of the T-80—T-80, T-80A, and T-80B.

[redacted]

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Table 6
Soviet T-64A and T-72 Weapons and Fire-Control Systems

| | T-64A | T-72 |
|--------------------|--|--|
| Main gun | 125-mm D-81 smoothbore with 40 rounds including 28 in autoloader | 125-mm D-81 smoothbore with 39 rounds including 22 in autoloader |
| Gunnery devices | TPD2-49 elevation-stabilized day sight with coincidence rangefinder and mechanical-analog ballistic computer TPN1-49-23 gunner's active-IR night sight L-2AG tungsten white/IR searchlight or newer xenon white/IR searchlight | TPD2-49 elevation-stabilized day sight with coincidence rangefinder and mechanical-analog ballistic computer TPN1-49-23 gunner's active-IR night sight L-2AG tungsten white/IR searchlight or newer xenon white/IR searchlight |
| Gun drive | Stabilized electrohydraulic drive | 2Eh28 stabilized electrohydraulic drive |
| Commander's sights | TKN-3 cupola periscope with active-IR channel OU-3G white/IR cupola spotlight | TKN-3 cupola periscope with active-IR channel OU-3G white/IR cupola spotlight |
| AA machinegun | 12.7-mm machinegun fired from inside closed cupola | 12.7-mm NSV machinegun with K10-T sight on ZU-72 cupola mount; fired from open cupola |
| Coaxial machinegun | 7.62-mm PKT, aimed by TPD2-49 sight | 7.62-mm PKT, aimed by TPD2-49 sight |

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Soviet Coincidence-Rangefinding Tanks: T-64A and T-72. T-64A and T-72 weapons and fire-control systems are nearly identical (see figure 4). T-64As and T-72s have the same 125-mm smoothbore gun, designated the D-81, and fire the same 125-mm ammunition. The coincidence-rangefinding bases can be seen extending across the front of the turrets and have left and right optics. The daytime gunsights used to aim the guns are automated periscopes containing the coincidence rangefinders, mechanical analog ballistic computers, and elevation-reference gyroscopes to directly stabilize the sight elevation. The computers are camshafts, with a cam for each ammunition type, rotated by gears engaged to the rangefinder drive. When the ammunition is selected, the appropriate cam is engaged with the reticle. The cams shift the reticles off the target in the gunsight as the rangefinder operates, showing the gunner where to aim.

The T-64A and T-72 gun drives use feedback circuits to drive the gun elevation to follow the elevation-reference gyroscopes inside the gunsights and to drive the turret azimuth to follow azimuth-reference gyroscopes under the gun cradles.

Equipment in the T-64A and T-72 commander's positions not seen in previous Soviet tanks is mostly semiautomatic-backup controls for use when the autoloaders have partial failures. The T-64A cupola is a new Soviet design that allows the commander to fire the AA gun from within the closed cupola.

T-64A and T-72 night-vision devices are in the same series of active-IR night sights and searchlights used in T-54s, T-55s, and T-62s. The T-64A and T-72 commander's sights are the same ones used in the T-62.

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[redacted] we believe the T-64A and T-72 gun drives are identical. The autoloader components are different, with some hydraulic components in the T-64A and all-electro-mechanical components in the T-72. The T-64A and T-72 guns may have different production designators because of the slightly different external breech fittings needed to interface with the different autoloaders. [redacted]

T-64A and T-72 fire-control systems indicate only gun elevation adjustments to compensate for target ranges and ammunition selection. The tanks cannot automatically adjust their aim for atmospheric conditions, cant, or moving targets. The reason for this is the simple design of the fire-control computers, which can shift the reticles only in elevation and have cams machined for standard ammunition and atmospheric conditions. Further aim adjustments would require azimuth-shifting reticles and machinery to compensate for nonstandard ammunition and atmospheric conditions. [redacted]

T-72s and probably T-64As can fire on the move with the aid of their stabilized gun drives, coincidence-firing circuits, and optionally engaged devices called Delta-D devices by the Soviets. The stabilizer circuits keep the guns on inertial azimuth and elevation angles. The inertial angles are set by reference gyroscopes. The gunners steer the guns by precessing the gyroscopes, and the stabilizers drive the guns toward the gyroscope angles. The Delta-D device can automatically update target range inputs as the tank moves closer to or further from the target. The device turns the ballistic camshaft, after initial rangefinding, at a rate proportional to the range rate caused by tank motion. The Delta-D device does not update ranges that change because of target motion and cannot track targets. [redacted]

Soviet Tanks Without Coincidence Rangefinders.
T-64B. T-64Bs do not have the coincidence-rangefinding bases found on T-64As. The single T-64B gunsight optic is on the left side and is much larger than the corresponding left rangefinding optic on the T-64A. A box-shaped housing of unknown function is on the right side of the T-64B, where the right rangefinding optic is found on the T-64A (see figure 5). Missile-guidance links could be part of this platform. The T-64B uses a different rangefinder from

that on the T-64A, but we have not confirmed the type. A laser rangefinder is the most likely choice, based on the widespread use of laser rangefinders on other tanks. [redacted]

25X1

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We believe that the T-64B ATGM guidance system is probably a semiautomatic command-to-line-of-sight (SACLOS) system using a radiofrequency command link from the tank to the missile. [redacted]

25X1

The externally observable T-64B night-vision devices look like the same infrared searchlights and night-sight housings used on the T-64A. The T-64B probably has the same night capability for firing conventional tank ammunition as the T-64A. We do not know whether the T-64B is equipped for night launching of ATGMs. New sights for passive night viewing or night ATGM launches may be under the T-64B's enlarged left optic, right-side turret housing, or gunner's active-IR night-sight housing. [redacted]

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We do not know whether the ATGM can be launched while the tank is moving. [redacted]

25X1

T-72 Variants and T-80. Bulgarian and Hungarian T-72s photographed by NATO attaches in 1981 and 1982 had the normal T-72 coincidence-rangefinding bases, but their right optics were blocked by opaque covers. The left optical window of one of the Hungarian tanks was also reported to be enlarged and divided in half. The modified Bulgarian and Hungarian T-72s were never given unique designators. [redacted]

25X1

T-72 variants without coincidence rangefinding bases and right rangefinding optics have been observed since 1980. These include the variant identified as a T-80. Their left optics are the main gunsights, which are larger than the left optics of the standard T-72s. In addition, the left optics often appear in NATO attache photographs to be vertically divided in half. [redacted]

25X1

The fire-control systems of the modified Bulgarian and Hungarian T-72s and T-72 variants may be similar or identical because the same externally observable fire-control changes are on all of these

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Figure 5. Soviet T-64B tank.



tanks—the standard coincidence-rangefinding base is not used, leaving their single left optics for rangefinding and gunnery. We do not know what fire-control devices are inside the tanks.

The rangefinders for the T-72 variants must fit under the left optics of the tanks. Laser rangefinders are likely candidates, especially considering special intelligence and emigre reports on T-72 variants with laser rangefinders.

The nature of the ballistic computing devices on the T-72 variants depends on the interface of the new rangefinders and the tank fire-control devices. The new rangefinders may only indicate range measurements to the gunners, who would manually enter the ranges into ballistic computers. Alternatively, the new rangefinders may automatically feed range signals directly into the computers. In either case, the computers could be anything from mechanical analog devices, as in the T-64A and T-72, to all-electronic digital circuits, as in modern Western tanks.

There are some indications of changes to the gun drives or the links between the guns and sights of the T-72 variants. We assume that these tanks can fire conventional ammunition on the move.

The night-vision devices on the T-72 variants are the same types of active-infrared sights and searchlights found on T-64As and T-72s. The enlarged left optics or the gunner's night-sight housing of the T-72 variants may house new passive gunnery sights.

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Sweden

Sweden

Sweden builds the only fielded turretless main battle tank, the Stridsvagn-103B (Strv-103B), commonly called the S-tank. The Swedish firm Bofors built 300 Strv-103s from 1966 to 1971 for the Swedish Army. Although Strv-103s have been tested by other countries, none have been exported. []

All Strv-103s are the B version. Strv-103As were early production models and did not have the amphibious capabilities of the Strv-103Bs. The Strv-103As were later modified to Strv-103Bs. []

The other tanks in the Swedish Army are the Strv-101 and Strv-102. These tanks are Centurion tanks imported from the UK. []

Strv-103B

The gun is fixed in the Strv-103B tank hull because the tank has no turret. The gun is loaded by an autoloader. The Strv-103B crew consists of the commander, gunner-driver, and a radio operator. The commander or gunner-driver can aim the gun with reticles in his periscopic sights []

The main gun is a 105-mm, Swedish-modified, L7-series rifled gun designated the L74. Because the gun barrel is rigidly mounted and supported over much of its length, it is made longer—62 calibers—than other L7 gun barrels. The longer barrel provides a higher muzzle velocity than that of L7 guns. The L74 breechblock is split into halves; one opens upward and one downward. The split breech saves space in the low-profile hull. []

The gunner-driver aims with an OPS-1 binocular periscope made by the Swedish firm Jungner. The aiming reticle is in the right eyepiece. The magnification and field of view can be adjusted for driving or gunnery. The field of view is 100 degrees at unity power for driving. The sight magnification can be stepped to 6, 10, or 18 power for gunnery. []

Table 7
Strv-103B Weapons and
Fire-Control Systems

| | | |
|-----------------|--|------|
| Main gun | 105-mm L74 with 50 rounds in automatic loader | 25X1 |
| Gunnery devices | OPS-1 periscope for gunner-driver Modified OPS-1 periscope in azimuth-stabilized cupola for commander | 25X1 |
| Gun drive | Nonstabilized electrohydraulic vehicle suspension | 25X1 |
| Other weapons | Two 7.62-mm Ksp58 coaxial machineguns One 7.62-mm Ksp58 AA machinegun Eight grenade launchers Two top-mounted Lyan launchers firing illumination rounds | 25X1 |

The commander sits in a cupola mounted directly on the hull. The cupola can traverse 104 degrees to either side and is traverse-stabilized. The sight is an OPS-1 with two modifications: its line of sight is elevation-stabilized from -11 to 16 degrees and the left eyepiece has index marks to enable the commander to align the cupola with the hull. []

The OPS-1L, a variant of the OPS-1 sight, has been designed for use with a laser rangefinder, but it has yet to be fitted to Strv-103B tanks. []

The variable suspension can elevate the gun from -10 to 20 degrees. The gun is aimed in azimuth by turning the tank. The suspension can be varied while the Strv-103B is moving, but the tank cannot fire on the move because the suspension is not designed to provide sufficient elevation stabilization. []

The autoloader holds all 50 main gun rounds in 10 racks of five rounds each. Charge cases are automatically ejected outside the tank upon firing. If the autoloader malfunctions, the radio operator can hand-crank the loading mechanisms. []

Switzerland

Secret

Switzerland

The Swiss Army has British-made Centurion and Swiss-made Pz61 and Pz68 tanks. Switzerland is evaluating the German Leopard II and US M-1 tanks, with a decision to procure one of the two types expected in 1983. [redacted]

The Swiss Centurions are the Marks 5 and 7, designated the Pz55 and Pz57 in the Swiss Army. About a third of the 320 Swiss Centurions are Mark 5's received from the UK, another third are surplus Mark 5's received from South Africa after 1960, and the last third are Mark 7's from the UK. These tanks are described in the UK Centurion section. [redacted]

The Swiss Army received 150 Pz61s from December 1965 to the end of 1966. Pz68s have been delivered in four batches (Marks 1 through 4), each with slight modifications. The Swiss Army received 170 Pz68 Mark 1's from 1971 to 1974, 50 Mark 2's in 1977, 110 Mark 3's from 1978 to 1979, and 60 Mark 4's from October 1981 through 1982. [redacted]

Pz61 and Pz68

The Pz61 and Pz68 fire-control systems consist of coincidence rangefinders, gunner's periscopes, coaxial telescopes, and electrohydraulic gun drives. The

rangefinders have 155-cm bases and 8-power fields. The gunner's periscopes have aiming reticles with range marks. The guns are elevated until the appropriate range marks are on-target and then fired. The gun drive of the Pz61 is not stabilized and that of the Pz68 is stabilized in traverse and elevation. [redacted]

25X1
25X1

Most of the Pz61 and Pz68 tank components are Swiss-made. The tanks are assembled at the Eidgenössische Konstruktionwerkstätte (Federal Construction Works) in Thun. The tanks have 105-mm L7A1 main guns designed by the UK but made in Switzerland and called the Pz Kanon 61 guns. The Pz61 has a 20-mm coaxial cannon, the Masch Kanon Pz61, made by the Swiss firm Oerlikon. The optical instruments are made by the Swiss firm Wild Heerbrugg. The gun drives, however, are made by the French firm SAMM. [redacted]

25X1
25X1

The only known fire-control modification among the Pz68 batches is the provision of a thermal sleeve on the guns of Marks 2 through 4. The Mark 3 and 4 turrets are larger than the Mark 1 and 2 turrets, but we do not know if any fire-control changes were made [redacted]

25X1

Table 8
Pz61 and Pz68 Weapons and Fire-Control Systems

| | Pz61 | Pz68 Marks 1-4 |
|----------------|---|--|
| Main gun | 105-mm L7A1 | 105-mm L7A1 |
| Gunnery sights | 8-power periscope for gunner | Modified 8-power periscope for gunner |
| | Coincidence rangefinder for commander | Coincidence rangefinder for commander |
| Night sights | None | None |
| Gun drive | CH25 nonstabilized electrohydraulic drive | Probably CH25-series stabilized electrohydraulic drive |
| Coaxial weapon | 20-mm Oerlikon 5TGK automatic cannon | 7.5-mm MG51 machinegun |
| Other weapons | 7.5-mm MG51 AA machinegun | 7.5-mm MG51 AA machinegun |
| | Six 80.5-mm L-Pz51 grenade launchers | Six 80.5-mm L-Pz51 grenade launchers |

25X1

United Kingdom

Secret

United Kingdom

British-designed tanks in service or under development in the early 1980s are the Comet, Centurion, Chieftain, and Challenger tanks designed for the British Army and the Vickers Mark 1, Mark 3, and Valiant tanks built privately by Vickers Limited. All of the tanks have been exported except the Challenger, Chieftain 900, and Valiant, which are still in the prototype test stages. A version of the Chieftain called the Khalid is being built for Jordan. India built a licensed copy of the Vickers Mark 1 known as the Vijayanta. [redacted]

Leyland Motors built 1,200 Comets from September 1944 to May 1945. The British Army withdrew its last Comets from service in 1960. The Comet is in use in Burma, Finland, Ireland, and South Africa, but probably only for training. [redacted]

The Centurion tank was the British main battle tank of the post-World War II era until it was replaced by the Chieftain in the late 1960s. Thousands of Centurions in several variants were exported. Many have been upgraded and are in service in many countries. Centurions were used in the Korean, Indo-Pakistan, and Vietnamese wars and in all of the major wars in the Middle East since World War II, including the Israeli invasion of Lebanon in June 1982. [redacted]

A total of 4,423 Centurions of all types were built by the Royal Ordnance Factories, Vickers, and Leyland Motors between 1945 and 1962. At least 2,500 were built for export. Many Centurions in the British Army were exported as they were replaced by Chieftains. [redacted]

The Chieftain will be Britain's main battle tank until the Challenger enters series production in the mid-1980s. About 900 Chieftains were built for the UK from 1965 to the early 1970s. The tanks are deployed in nine British Army of the Rhine regiments and two domestic regiments. [redacted]

The computerized Integrated Fire-Control System (IFCS) designed by Marconi Space and Defence Systems is being installed, either as original equipment or a retrofit, in Khalids and all British Army Chieftains. [redacted]

Challenger, the newest tank design for the British Army, will begin entering service about 1985. It is regarded as a new-generation tank equivalent to the German Leopard II and US M1 tanks. Challenger will have nonhomogeneous armor and a version of the IFCS. [redacted]

25X1

Vickers Limited privately developed a tank in the late 1950s, hoping to sell it to lesser developed countries to offset the company's declining Centurion production. The tank, called the Vickers Mark 1, was adopted by the Indian Army in 1961. Production of the Mark 1, renamed the Vijayanta by India, began in 1965 at a Vickers-built plant in Avadi, India. About 1,200 Vijayantas had been produced by 1981. An unclassified arms market survey has stated that India is developing a successor to the Vijayanta, but we do not know the status of the program. In late 1980 India ordered Marconi Radar's Simplified Fire-Control System-600 (SFCS-600) for retrofitting into the Vijayanta. [redacted]

25X1

Vickers delivered 70 Mark 1's to Kuwait between 1970 and 1972. [redacted]

25X1

The Vickers Mark 2 was to carry two Swingfire ATGM launchers on the sides of the turret, but it was never produced. [redacted]

25X1

The Vickers Mark 3, which features a more advanced fire-control system than the Mark 1 and Vijayanta, was first ordered by Kenya in 1977. Vickers completed the first of 76 Mark 3's for Kenya in 1980. Vickers offers several options for the Mark 3, including the SFCS-600, 12.7-mm machineguns, passive night sights, and counterrotating cupolas. The cupolas on the Kenyan tanks are hand cranked and are not counterrotating. Nigeria ordered 47 Mark 3's with the SFCS-600 and passive Condor sights in August 1981. [redacted]

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Table 9
Centurion Mark 5 and Mark 13 Weapons
and Fire-Control Systems

| | Centurion Mark 5 | Centurion Mark 13 |
|--------------------|--|---|
| Main gun | 83.4 mm | 105-mm L7A1 or L7A2 |
| Gunnery devices | No. 1 Mark 1 or Mark 2 coaxial telescope Optional 1121/03 active-IR night telescope | No. 18 Mark 1 or Mark 2 or No. 30 Mark 1 day periscope Optional A-1198-A active-IR night periscope |
| Commander's sights | Optional 1210/03 active-IR periscope | 12.7-mm L21A1 ranging machinegun No. 4 Mark 2 day periscope |
| Active-IR Source | Optional white/IR searchlight | Optional white/IR searchlight |
| Gun drive | GCE No. 1 Mark 4/1, stabilized, all electric | Modified GCE No. 1, stabilized, all electric |
| Machineguns | 7.62-mm L8A1 coaxial machinegun 7.62-mm L37A1 AA machinegun | 7.62-mm L8A1 coaxial machinegun 7.62-mm L37A1 AA machinegun |

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Vickers developed a nonhomogeneous-armor prototype tank in the late 1970s. Testing of the new prototype tank, the Valiant, began in 1980. The final design has not been determined; the Valiant is being tested with the SFCS-600 fire-control system.

The following sections outline the development of the tanks from a weapon and fire-control viewpoint. The simpler fire-control systems are described in the appropriate tank development sections. However, the IFCS and SFCS-600 systems are discussed separately because both systems are being adapted for refitting to several late-model British tanks.

Comet

The main gun of the Comet is the 76.2-mm Ordnance Quick-Firing Mark 2. The gun is often listed as 77 mm to distinguish it from the 76.2-mm 17-pounder gun used on other British tanks of the late 1940s and early 1950s. The British used to designate their guns by ammunition weights; 17-pounders are 76.2-mm guns and 20-pounders are 83.4-mm guns. The 76.2-mm gun was designed to fire World War II armor-piercing, capped (APC) and HE rounds. We know of no Comet gun retrofits.

The other Comet weapons are 7.92-mm Besa machineguns mounted coaxially with the main gun and in the bow of the hull. The Comet was designed for a crew of five with a bow machinegunner next to the driver and the commander, gunner, and loader in the turret. Twelve smoke-grenade launchers are mounted on the turret.

Comet fire-control equipment is simple. The gunner has a coaxial telescope to point the main gun. The commander visually acquires targets and estimates ranges. The gun drive consists of an electric turret-traverse drive produced by the firm Lucas and manual gun-elevating gears. The turret and gun are not stabilized.

Centurion

The Centurion production variants—Marks 1 through 13—are the result of numerous engine changes, armor improvements, gun replacements, and fire-control changes by the British. Export customers, notably the

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Israelis, Jordanians, South Africans, Swedes, and Swiss, have continued to modify their Centurions. Changes have included modification of the cupola, gun mount, and gun drive and the addition of night-vision devices and ranging machineguns (RGMs). One military publication has claimed that the Israeli Centurions have undergone 2,000 modifications.

Most Centurions still in service probably have fire-control systems typified by those of the Centurion Mark 5 or Mark 13. The gunners aim with coaxial telescopes containing aiming marks or with RMGs. All Centurion gun drives are stabilized.

We are not confident that we have accurate information on the modifications to all of the Centurions in use worldwide. Many Centurions were exported and then reexported as client states bought more modern tanks.

The remainder of the Centurion section outlines the differences between the planned production models and those we know have been exported.

The Centurion went into production in 1945. One hundred Mark 1's and 250 Mark 2's were built from 1945 to 1948. The Mark 1's and 2's had 76.2-mm main guns and 7.92-mm Besa machineguns; Mark 1's also had a 20-mm Polsten cannon. The main guns were stabilized by electric gun drives. Some of the Mark 2's were exported to Canada and Denmark. All of the 76.2-mm guns on the Mark 2's, including those on the exports, were replaced by 83.4-mm guns in 1950-51, resulting in the Mark 3 design.

The Mark 3 had the largest production run of the Centurion program, with 2,833 built from 1947 to 1956. Mark 3's were exported to Egypt and South Africa, and they reached Israel through Germany in 1959.

Most of the Mark 3's were upgraded to Mark 5's. (The Mark 4 was never produced.) The Mark 5 was the most widely exported Centurion model. Of the over 3,000 Mark 5's resulting from the Mark 3 upgrade and production of 221 new Mark 5's in 1955-58, about 2,500 were exported to Australia, Canada, Denmark, India, Iraq, Israel, Jordan, Kuwait, Libya,

the Netherlands, South Africa, Sweden, and Switzerland. South Africa received its Centurion Mark 5's from the United Kingdom, India, Iraq, and Jordan. Switzerland received 100 surplus Mark 5's from South Africa about 1960. Swiss Mark 5's are designated the Pz55 tanks; Swedish Mark 5's, the Strv-101 tanks. Mark 5's were used by the British Army in the 1956 Suez Canal War.

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Many exported Centurions are probably in the basic Mark 5 configuration. The Mark 5 weapons are an 83.4-mm main gun and either M1919, L8, or L37 7.62-mm coaxial and top-mounted machineguns. The gunner aims the main and coaxial guns with a No. 1 Mark 1 or Mark 2 coaxial telescope. The telescope has a 6-power field with a ballistic reticle. The gun drive, commercially known as the EC517, is an all-electric GCE No. 1 Mark 4 mechanism that provides turret and gun stabilization.

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The Mark 5 was followed by the Mark 7. It consisted of a Mark 5 turret on a new Leyland hull that provided more fuel and ammunition stowage within the armor than previous Centurion hulls. The 455 Mark 7's built from 1953 to 1960 were exported to Australia, India, Israel, Kuwait, the Netherlands, South Africa, Sweden, and Switzerland. The 100 Swiss Mark 7's are designated the Pz57 tanks; the Swedish Mark 7's, the Strv-102 tanks

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The Mark 8 is a Mark 7 with a modified turret. The turret features a new counterrotating cupola for the commander, a new gun mount, and a new elevation mechanism in the gun drive. The new gun mount consists of resiliently mounted trunnions. It is designed to prevent shearing the gun off the trunnions if the barrel strikes an obstacle. A total of 108 Mark 8's were produced from 1955 to 1960, and several were exported to Israel.

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By the mid-1950s, most Mark 5's, 7's, and 8's had 83.4-mm guns. A major upgrading of the armor and guns on many of the Centurions began in the mid-1950s. A 105-mm gun was developed for the Centurion. It was the forerunner of the L7-series 105-mm

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guns on many Western tanks today. Basically, the Marks 5, 7, and 8 with improved armor are designated the Marks 5/1, 7/1, and 8/1 and the versions with 105-mm guns are the Marks 5/2, 7/2, and 8/2. Australia, Canada, Denmark, and the Netherlands installed 105-mm guns on their Centurions. The Marks 5, 7, and 8 with both improved armor and the 105-mm gun are designated Marks 6, 9, and 10 by the British. [redacted]

The Mark 10 was the last original-production Centurion. The gun drive was designed to turn on the stabilizer circuits automatically at vehicle speeds over 6.5 km per hour. From 1959 to 1962, 155 Mark 10's were produced, ending Centurion production. [redacted]

Subsequent Centurion modifications were smaller scale additions, consisting of active IR night sights and searchlights and 12.7-mm RMGs for the 105-mm main guns. Older infrared sights were the US 1121/03 gunner's sights, 1210/03 commander's sights, and A-1198-A general night periscopes. Most of the Centurions with IR sights had external stowage baskets on their bustles so the sights could be stored inside the turrets. The addition of IR sights to the Marks 6, 9, and 10 resulted in the Marks 6/1, 9/1, and 10/1; the addition of RMGs resulted in the Marks 6/2, 9/2, and 10/2. The addition of IR sights and RMGs to the Marks 6, 9, and 10 resulted in the Marks 11, 12, and 13. The Mark 13 was introduced in 1964, and it is the highest numbered Centurion variant. [redacted]

On the Mark 13, the commander's and gunner's periscope mirrors are mechanically linked, and both of their periscopes have the aiming scales for the main and coaxial guns. The RMG is used for rangefinding. Some Mark 13's have white/IR searchlights mounted left of the main guns and optional active-IR night sights. The Mark 13 has all-electric gun drives with stabilizing circuits. The commander can override the turret-traverse power but not the gunner's control of elevation. The gun drive has two powered modes of operation—a stabilized-azimuth, stabilized-elevation mode and a semiautomatic mode that only provides nonstabilized powered traverse. [redacted]

Modifications to Exported Centurions. Beginning in 1970, Israel upgraded its 400 Mark 5, 7, and 8 Centurions. Most or all of the Israeli Centurions were

equipped with 105-mm L7 or M68 guns. Night-vision sights and xenon searchlights were added. Some of the Israeli Centurions have Number 5210 Nd:YAG laser rangefinders made by the firm El-Op. Some Israeli Centurions also have two top-mounted 7.62-mm machineguns. [redacted]

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Jordanian Centurions are being retrofitted with the Belgian-made SABCA fire-control devices and US Cadillac Gage stabilization mechanisms. The SABCA devices are similar to those in Australian, Belgian, and Canadian Leopard I tanks. [redacted]

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South Africa probably has Centurion Marks 3, 5, and 7. South Africa may be retrofitting its Centurions. It [redacted]

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[redacted] is probably developing 105-mm guns for its Centurions. South Africa also has begun producing its own version of the Centurion, the Olifant (see the South African entry). [redacted]

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Both Sweden and Switzerland have considered retrofitting their Centurions (Swedish Strv-101 and -102 and Swiss Pz55 and 57) with a Vickers retrofit package. The retrofit would include a 105-mm gun (if the tank does not have one), an RMG for the 105-mm gun or an optional Marconi-L. M. Ericsson Nd:YAG laser rangefinder, a new commander's cupola with a 1- or 15-power sight and counterrotating option, passive night sights, and the EC750 stabilized gun drive. The EC750, designed by Marconi Radar Systems in Leicester, United Kingdom, is a modularized, easily installed system intended for fitting by the customer. [redacted]

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Chieftain, Khalid, and Challenger

The Chieftain Marks 1 through 12 are characterized by various retrofittings of the initial production versions of the tank. The first Chieftains, the Mark 1's, were training models issued to the British Army from 1965 to 1967. The Mark 2's entered service in 1967 and the Mark 3's in 1969. The Marks 3/G, 3/2, and 3/S were Mark 3's with ventilation modifications for the turrets and engines. These early Chieftains used coaxial RMGs. [redacted]

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The Mark 3/3 was a Mark 3 with an extended-range RMG and the first fitting of a laser rangefinder, which would later replace the RMG, in a Chieftain. The Mark 3/3 had a laser rangefinder fitted in 1970. Beginning in 1971, some Mark 3/3 tanks were exported to Iran. [redacted]

Further development of the Mark 3/3, including fire-control changes, resulted in the Mark 5. (The Mark 4 was never produced.) About 770 of the British Chieftains were Mark 3's and 5's in the mid-1970s. Britain exported about 700 Mark 5's to Iran, with delivery ending in 1978, and 160 Mark 5's to Kuwait with delivery ending in 1979. Iraq has captured some Iranian Chieftains, probably Mark 5's, during the Iran-Iraq war that started in September 1980. Iraq may have sent many of the captured Chieftains to Jordan. [redacted]

Further engine and RMG modifications of the Marks 2, 3, and 3/3 resulted in the Marks 6, 7, and 8, respectively. [redacted]

In 1974 Iran ordered the Shir I and Shir II Chieftain variants, but it canceled the order in 1979 before any deliveries. The Shir I was a Chieftain Mark 5 with a modified engine and fire-control system; the IFCS was added to the Shir I, which was offered to Jordan under the name Khalid. Jordan has received the first of an order of at least 278 Khalids. The Shir II was a nonhomogeneous-armor design that became the basis of Britain's newest tank, the Challenger. [redacted]

In the last half of the 1970s, Marconi Space and Defence Systems Ltd. developed the IFCS for use in Chieftain tanks. The United Kingdom intends to retrofit all of the Chieftains it has in service with the IFCS. After the retrofits, the Marks 6, 7, 8, and 5 will become the Marks 9, 10, 11, and 12, respectively. None of the exported Chieftains except the Jordanian Khalid have the IFCS. [redacted]

Chieftain and Khalid. All current Chieftain fire-control systems are probably similar or identical to the IFCS fitted in the Mark 12 or the systems of the Marks 3, 3/3, or 5. [redacted]

The 120-mm L11-series Chieftain guns fire APDS and HESH ammunition. The charges are stowed in water bins in many Chieftains as a fire prevention

measure. Smoke rounds, which are ballistically matched to the HESH rounds, are available. The United Kingdom requires the 120-mm guns to fire 10 rounds per minute for the first minute and 6 rounds per minute for the next four minutes. [redacted]

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The main fire-control difference between the Marks 3 and 3/3 is the rangefinding equipment. The Mark 3 uses a 12.7-mm coaxial RMG. The RMG rounds were initially ballistically matched to the HESH main rounds over the first 1,800 meters; in the 1970s, rounds matched over the first 2,500 meters were issued. No ranging has been practiced for APDS rounds fired at ranges of less than 1,000 meters. The commander fires the RMG and can fire the main gun. [redacted]

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In 1970 the gunner's sight on the Mark 3/3 was fitted with a Barr and Stroud LF2 laser rangefinder. The LF2 could measure ranges out to 5,000 meters with an accuracy of 10 meters. A new gunner's mount was developed for the LF2-equipped sight. Because the RMG trajectories showed the crew how to correct for cant angles and the laser rangefinder did not, a cant sensor and corrector were installed in the LF2-equipped sight. [redacted]

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Chieftain Marks 3 and 3/3 tanks have L1A1 night sights for the commander's and gunner's periscopes. The night sights have IR-to-visible converters that require active-IR sources. Chieftains have a 2-kilowatt (kW) xenon white/IR searchlight permanently mounted in an armored housing on the left side of the turret. The searchlight mirror, which directs the elevation of the light beam, is mechanically linked to the main gun. [redacted]

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The Chieftain Marks 3 and 3/3 gun drive is a stabilized, all-electric drive that uses metadyne controllers. [redacted]

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As originally fitted, the Mark 5 fire-control system has a few minor modifications compared with the Mark 3/3. The gunner's telescope contains a reticle for the extended-range RMG rounds. (The Chieftains retained the RMG, even with the laser rangefinders.) [redacted]

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Table 10
Chieftain and Khalid Weapons and Fire-Control Systems

| | Chieftain Mark 3 | Chieftain Mark 3/3 | Chieftain Mark 5 | Chieftain Mark 12 | Khalid |
|--------------------|----------------------------------|--------------------------------------|---|---|---|
| Main gun | 120-mm L11A2 or L11A3 | 120-mm L11A2 or L11A3 | 120-mm L11A3 or L11A5 | 120-mm L11A5 | 120-mm L11A5 |
| Gunnery devices | No. 38 Mark 1 day periscope | LF2 laser rangefinder | Barr & Stroud tank laser sight unit containing Nd:YAG laser | Barr & Stroud tank laser sight unit containing Nd:YAG laser | Barr & Stroud tank laser sight unit containing Nd:YAG laser |
| | .50-caliber L21 RMG | .50-caliber L21A1 extended-range RMG | .50-caliber L21A1 extended-range RMG | No RMG | No RMG |
| | L1A1 active-IR periscope | L1A1 active-IR periscope | L3A1 active-IR periscope | L4A1 active-IR periscope | No active-IR sights |
| | Xenon search-light | Xenon search-light | Xenon search-light | Xenon search-light | |
| | No. 26 Mark 1 coaxial telescope | No. 26 Mark 1 coaxial telescope | No. 26 Mark 1 coaxial telescope | No. 26 Mark 1 coaxial telescope | No. 26 Mark 1 coaxial telescope |
| Commander's sights | No. 15 cupola | No. 15 cupola | No. 15 cupola | No. 15 cupola | No. 15 cupola |
| | No. 37 Mark 3 or 4 day periscope | No. 37 Mark 3 or 4 day periscope | No. 37 Mark 3 or 4 day periscope | No. 37 Mark 3 or 4 day periscope | Pilkington Condor passive day/night sight |
| | L1A1 active-IR night periscope | L1A1 active-IR night periscope | L1A1 active-IR night periscope | L1A1 active-IR night periscope | |
| Gun drive | Stabilized all electric | Stabilized all electric | GCE No. 7 Mark 4 stabilized all electric | GCE No. 10 or 11 stabilized all electric | GCE No. 10 or 11 stabilized all electric |
| Other weapons | 7.62-mm L8A1 coaxial machinegun | 7.62-mm L8A1 coaxial machinegun | 7.62-mm L8A1 coaxial machinegun | 7.62-mm L8A2 coaxial machinegun | 7.62-mm L8A2 coaxial machinegun |
| | 7.62-mm L37A1 AA machinegun | 7.62-mm L37A1 AA machinegun | 7.62-mm L37A1 AA machinegun | 7.62-mm L37A2 AA machinegun | 7.62-mm L37A2 AA machinegun |

The commander's sights are the same except that an extended-range RMG reticle was installed in the collimator. []

Chieftain, Khalid, and Challenger Tanks With IFCS. The IFCS is basically a Chieftain Mark 5 fire-control system with automatic sensors and a digital computer added to generate ballistic solutions. It consists of the computer, gunner's and commander's sights and controls, sensors, and gun drive. []

The Chieftain and Khalid IFCS computer is a Marconi 12-12P electronic digital computer. The Challenger IFCS may use a Ferranti F100-L computer; the United Kingdom had not made its final decision as of mid-1983. []

The gunner's sight is a British Barr and Stroud tank laser sight (TLS) containing a Nd:YAG laser rangefinder. The sensors developed for the IFCS measure

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cant angle, sight elevation, air pressure, air temperature, ammunition temperature, windspeed, gun and turret positions, and traverse and elevation rates. The gun drive is a stabilized, all-electric drive using gyroscopes and amplidyne to keep the gun steady while the tank is halted or moving. []

The different versions of the IFCS work alike, but contain different sets of automatic sensors. The computer processes the sensor inputs to generate the aiming angles for the gun. The angle signals are sent from the computer to the gunner's sight. []

An IFCS engagement begins when the commander acquires a target, issues firing orders, and traverses the turret toward the target. The loader loads the gun with the ammunition specified by the commander as the turret traverses. The gunner acquires sight of the target in the TLS and presses the appropriate ammunition selection button on his gun-control handle. []

The IFCS computer positions two reference marks in the gunner's TLS: a muzzle-boresight mark and an aiming mark. The muzzle-boresight mark shows where the gun is pointing and is constantly displayed. The muzzle-boresight mark can be checked periodically for alignment with the gun from within the tank with the aid of a muzzle-reference system supplied with the IFCS sensors. The aiming mark is an ellipse projected into the TLS field of view after rangefinding and is used to aim the gun. []

After the gunner has the target in sight and the ammunition has been selected, he places the muzzle-boresight mark on the target (by operating the gun drive) and fires the laser rangefinder. Laser-firing initiates the computation sequence. The computer accepts inputs from the laser rangefinder, other automatic sensors, and the commander. The computer begins computing and projects the aiming mark into the gunner's sight. The size of the aiming mark is automatically adjusted for the range reading so that the ellipse just fits around a tank-size target image. []

At this point, the gunner presses an "Autolay" switch on his control handle and begins the aiming sequence. When the computer has computed the aiming angles, it indicates the angle to the gunner by shifting the []

aiming mark off the target by a vertical angle equal and opposite to the superelevation angle and a horizontal angle equal and opposite to the azimuth-offset angle. If the gunner keeps the Autolay switch depressed, the gun shifts up by the superelevation angle and over by the azimuth-offset angle. The aiming mark shifts back onto the target, and the muzzle-boresight mark shifts off the target. When the aiming mark is back on target, the gunner can fire the gun. []

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The gunner can aim the gun without keeping the Autolay switch depressed by using the thumb joystick on his control handle to move the gun and turret. []

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If a target is moving, the gunner must track it for one to five seconds after the laser is fired. The gunner tracks the target by moving the gun and turret to keep the muzzle-boresight mark on the target image. Sensors in the gun drive feed azimuth and elevation rates into the computer. These rates are used to compute lead angles that are added to the aiming angles. After the initial tracking period, the gunner presses the Autolay switch and the aiming sequence progresses to firing. []

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The commander in an IFCS-equipped tank can also aim and fire the gun. The computer-generated marks are projected into his sight (a modified Chieftain No. 37 periscope). The commander's control handle is the same as that of the gunner, except the commander can override the gunner. []

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Vickers Tanks With SFCS-600

The SFCS-600 is a computer-controlled fire-control system designed in the late 1970s by Marconi Radar Systems Limited. We are less sure of the exact configuration of an SFCS-600 than that of present IFCSs because it is more modular, is a more recent development, and few have been built. Generally, the SFCS-600 has fewer automatic sensors than the IFCS, and the SFCS-600 sequence usually requires a small final aiming correction by the gunner. However, the electronic technology in the SFCS-600 is as sophisticated as that of the IFCS. []

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The SFCS-600 is primarily intended as an export system for retrofitting into Centurion, Chieftain, and Vickers tanks. The only confirmed SFCS-600 orders are the Indian order for the Vijayanta tanks and a Nigerian order for Vickers Mark 3 tanks. [redacted]

The SFCS-600 consists of a computer, a laser-rangefinding gunner's sight, and a few sensors. It does not include a gun drive because it is intended for retrofitting into tanks with powered gun drives. The installation of an SFCS-600 into a tank would involve fitting of traverse- and elevation-rate sensors and rate controllers into its gun drive. [redacted]

The SFCS-600 computer is a Marconi EC-600 digital electronic computer. The computer contains a US Intel 8085 microprocessor with several read-only memories (ROMs). The ROMs are used to store ammunition characteristics; ROMs that are matched to the ammunition used by the tank being fitted would be supplied with each SFCS-600. The SFCS-600 configuration can be adapted to accept at least three gunner's sights with Nd:glass or Nd:YAG laser rangefinders: the British Barr and Stroud TLS used in Chieftains, the British Avimo Company's LV2 sight, and the Norwegian Ericsson Company's tank laser-rangefinding sight. The SFCS-600 computer can be adapted to accept inputs from automatic sensors such as those used in the IFCS. However, the SFCS-600 was designed to accept manual inputs of some of the ballistic factors measured automatically in the IFCS, bypassing the requirement for costly sensors. The SFCS-600 usually includes a cant sensor. [redacted]

Target engagement with the SFCS-600 is similar to that of the IFCS. Two marks are projected into the gunner's sight—a permanent cross showing the true muzzle-boresight position and an aiming spot projected after computation of the aiming angles. The gunner uses the gun-drive controls in the tank to steer the gun and turret until the cross is on target. If the target is moving, the gunner tracks it by keeping the cross on target. When the gunner judges that the turret-traverse motions are sufficiently smooth, he depresses an initiation button. This begins feeding azimuth and elevation rates into the computer from the gun drive in preparation for ballistic computation. After a few seconds, the gunner releases the initiation button. [redacted]

Upon release of the initiation button, the SFCS-600 begins automatic aiming. The laser rangefinder fires and ranges, and other inputs enter the computer. The computer calculates the aiming angles, and the aiming spot appears in the gunner's sight. The spot immediately appears offset by angles equal and opposite the aiming angles. The computer then automatically sends control signals to the gun drive, and the gun drive traverses the turret and elevates the gun by amounts approximately equal to the aiming angles. This causes the aiming spot to approach the target, flickering in intensity as it moves. When it is on or near the target, the intensity of the spot is steady. The gunner makes the final aiming correction by moving the gun until the spot is on target and then fires. [redacted]

The commander may or may not be able to use the SFCS-600, depending on how the system has been fitted. Many commander's sights can be adapted to be used with the SFCS-600. For example, the British Pilkington Condor sight, a passive day/night sight using image intensifiers, can be adapted for use with the SFCS-600. India may procure these sights, and the Valiant prototype is being tested with the SFCS-600 and the Condor sights. [redacted]

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United States

United States

Except for the new M1 tank, US tanks—M60s, M48s, M47s, and M4s—are in worldwide service today. The M1 entered series production for the US Army in 1981 and is being evaluated for possible procurement by Switzerland. The M60 family of tanks are the most numerous in the US Army, and large numbers of M48s also are in service. Older M47s and M4s are no longer used by the US Army but still are used by several other countries. [redacted]

The most extensive fire-control changes in post-World War II US tanks occurred during the evolution of the M48 and M60 series of tanks. Many new devices for rangefinding, computing, aiming, and night vision were developed for the middle and later models of each series, and the devices were retrofitted on earlier models. M48s and M60s in the US Army have been upgraded to become M48A5s and M60A3s. There are two M60A3 versions—one with and one without a thermal-imaging sight. Technologically, the M1 fire-control system is equivalent to that of the thermal-imaging version of the M60A3, although the fire-control hardware in the M1 and M60A3 are different. [redacted]

M48s and M60s have been exported for the last 25 years. Many of the older M48s in foreign armies have been upgraded to M48A5 standards, and several countries are buying retrofit kits to upgrade their older model M60s to M60A3 standards. [redacted]

Most M4s and M47s were exported in the 1950s. Most major fire-control modifications on the M4s and M47s were done for foreign armies by US and foreign contractors. [redacted]

M4 Sherman Tank Models

The M4 Sherman tank was originally used in World War II. The major differences among the many M4 models were the gun sizes, ammunition stowage, armor construction, engine types, and suspensions. Fire-control changes were the result of gun changes. The M4 fire-control system consisted of a periscope linked to the gun elevation and a coaxial telescope.

The periscope and telescope had fixed reticles for aiming the gun; the reticles had to be changed when a different gun was fitted. Changing to a larger gun also required modification of the gun mount, gun drive, and sometimes the entire turret. [redacted]

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The production model tanks—the original M4, M4A1 through M4A4, and M4A6 were built with either short-barreled, 75-mm M3 guns or longer barreled, 76.2-mm M1A1 or M1A2 guns. The M4A5s were built by Canada with 57-mm guns. [redacted]

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The British refitted their M4s with 83.4-mm 17-pounder guns in World War II and called the tanks the "Fireflies." M4 Fireflies are still in service in Argentina and Yugoslavia. [redacted]

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Israel received many M4s from France in the mid-1950s. Some of the Israeli M4s with 76.2-mm guns were designated M1s by Israel. Both Israeli and Egyptian M4s were refitted with French 75-mm high-velocity guns, designated the CN-75-50s, by two competing French companies in the mid-to-late 1950s. Schneider-Creusot did the work for Israel; Batignolles-Chatillon, for Egypt. The Israelis called their M4s with French 75-mm guns the M50s. M50s are still in service with the Christian Militia in Lebanon. [redacted]

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Israel later fitted M4s with 105-mm guns, designating the newly fitted tanks as M51s and the guns D1504-L/44s. The D1504 guns were Israeli-made, shorter barreled (44 caliber) versions of the French CN-105-F1 (56 caliber) guns now used on the AMX-30 tanks. [redacted]

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Since 1973 many of the aging Israeli M4s have been converted into artillery pieces; observation vehicles; or noncombatant utility, recovery, and ambulance vehicles. Israeli M4s were not used in advance Israeli units in the invasion of Lebanon in 1982. [redacted]

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Table 11
M47 Weapons and Fire-Control Systems

| | |
|-------------------|--|
| Main gun | 90-mm M36 rifled gun |
| Gunnery devices | M20 periscope |
| | M12 stereoscopic rangefinder |
| Commander's sight | M20 periscope |
| Gun drive | Nonstabilized, manually operated, hydraulically assisted system |
| Other weapons | 7.62-mm M1919 coaxial and bow machineguns .50-caliber M2-HB AA machinegun |

M47

The M47 was the first US tank with a nonstadiametric rangefinder and ballistic computer and the last tank produced in the world for a crew of five. Original M47s have 90-mm M36 rifled guns. [redacted]

The M12 sight in the M47 consists of a stereoscopic rangefinder combined into a primary aiming sight for the gunner. The M47 ballistic computer consists of ballistic cams in the M12 sight. The gunner manually adjusts the cams by selecting the correct cam and dialing in the measured target range. The cams transmit the correct superelevation angles to the sight reticles. M12 sights are being produced in Italy. [redacted]

For observation, the M47 commander and gunner have M20 periscopes, and the other crew members each have an M13 periscope. [redacted]

Exported M47 Tanks. The United States began exporting M47s in 1954, and they are still in wide service. The fire-control systems on some M47s were modified during the 1970s. [redacted]

France, Iran, Israel, and Italy have fitted 105-mm guns on some of their M47s. The 105-mm M47s are sometimes called M47 RKM by Israel and M47M by Iran. The 105-mm guns are the CN-105-F1 in France, M68 in Israel, and L7 in Italy. [redacted]

Iranian M47s are being upgraded with 105-mm guns of unknown origin at an Iranian plant that was built by the US firm Bowen-McLaughlin-York (BMY) in

1970-72. NATO attaches have reported that the M47 is also being fitted with a new fire-control system said to be equivalent to that of the M60A1. The Iranian plant is also providing new 90-mm guns for Pakistani M47s. [redacted]

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Spain has rebuilt 385 M47s with new fire-control systems. These M47s are sometimes called either M47S or M47E tanks. NATO attaches have reported that the new fire-control system is equivalent to that of the M60A1. [redacted]

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M48

Production of the first M48s was completed in 1952. The early M48 fire-control technology was similar to that of the M47, but the M48 commander had the stereoscopic rangefinder. The commander called out the range, and the gunner responded by indexing the range on a ballistic drive linked to the gunner's periscope. Setting the ballistic drive shifted a reticle in the periscope eyepiece. The gun was elevation linked to the periscope; raising the gun caused the target image to shift back to the reticle, at which time the gun was ready to fire. Another difference between the M48 and M47 was the fitting of a Cadillac Gage nonstabilized, electrohydraulic gun drive in the M48. An override switch in the electrical circuits to the hydraulic pumps enabled the commander to quickly override the gunner's control of the traverse. [redacted]

25X1

The M48s before the M48A1 had the first ballistic computer on a US tank. The ballistic computer consisted of a separate cam-operated mechanism linked by shafts to the rangefinder and ballistic drive. The gunner switched the appropriate cams to select the correct mechanical algorithm for the loaded ammunition. The range automatically entered the computer by rotation of the rangefinder shaft, and the computer-output gun elevation was then automatically transmitted to the periscope reticle by rotation of the ballistic drive shaft. [redacted]

25X1

Incremental fire-control changes continued in the first M48A2 and M48A2C models. For example, the M48A2C had a temperature-compensated ballistic drive and a quicker traverse override for the commander. Later M48 models incorporated more significant changes. [redacted]

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Table 12
M48 Weapons and Fire-Control Systems

| | M48 | M48A1 | M48A2 | M48A2C | M48A3 | M48A5 |
|---------------------|---|--|-------------------------------------|-------------------------------------|--|--|
| Main gun | 90-mm M41 rifled gun | 90-mm M41 rifled gun | 90-mm M41 rifled gun | 90-mm M41 rifled gun | 90-mm M41 rifled gun | 105-mm M68 rifled gun |
| Gunnery devices | M20 periscope | M20 periscope | M20 periscope | M20 periscope | M32 periscope with active-IR night channel | M32 periscope with active-IR night channel |
| | M5 ballistic drive | M5 ballistic drive | M5 ballistic drive | M10 ballistic drive | M10A6 ballistic drive | M10A6 ballistic drive |
| | M97C coaxial telescope | M97C coaxial telescope | M97C coaxial telescope | M97C coaxial telescope | M105 coaxial telescope | M105 coaxial telescope |
| | M13 analog mechanical computer | M13 analog mechanical computer | M13 analog mechanical computer | M13 A1C computer | M13B1C analog mechanical computer | M13B1C or M13A4 analog mechanical computer |
| | No night-vision aids | No night-vision aids | AN/VSS-1 xenon white/IR searchlight | AN/VSS-1 xenon white/IR searchlight | AN/VSS-1 xenon white/IR searchlight | AN/VSS-1 xenon white/IR searchlight |
| Commander's devices | No cupola | M1 manually traversed cupola | M1 cupola | M1 cupola | M1 cupola | Low-profile cupola |
| | M13 stereoscopic rangefinder | M13 stereoscopic rangefinder | M13 stereoscopic rangefinder | M17 coincidence rangefinder | M17 coincidence rangefinder | M17 coincidence rangefinder |
| Gun drive | Nonstabilized electrohydraulic systems (all M48s) | | | | | |
| Other weapons | .30 caliber M1919A4 coaxial machinegun | .30 caliber M1919A4 coaxial machinegun | 7.62-mm M73 coaxial machinegun | 7.62-mm M73 coaxial machinegun | 7.62-mm M73 coaxial machinegun | 7.62-mm M219 coaxial machinegun |
| | M2-HB AA machinegun | M2-HB AA machinegun | M2-HB AA machinegun | M2-HB AA machinegun | M2-HB AA machinegun | 7.62-mm M60D AA machinegun |

The M13-series stereoscopic rangefinders were replaced by M17-series coincidence rangefinders in the M48A2C. The coincidence rangefinders became the standard rangefinder and were retrofitted into older M48s. The ballistic drives were changed on the M48A2C to accommodate the coincidence rangefinders.

The M48A2 and M48A2C tanks had a night-firing capability provided by 2.2-kW AN/VSS-1 xenon searchlights. These searchlights and their successors, the 1-kW AN/VSS-3 searchlights, are the US Army's standard white light or near-IR sources for tanks.

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Table 13
M60 Weapons and Fire-Control Systems

| | M60 | M60A1 Passive | M60A1 AOS | M60A2 | M60A3 | M60A3 Thermal |
|---------------------|--|---|---|--|---|---|
| Main gun | 105-mm M68 rifled gun | 105-mm M68 rifled gun | 105-mm M68 rifled gun | 152-mm M162 tube firing Shil- lelagh missiles | 105-mm M68 rifled gun | 105-mm M68 rifled gun |
| Gunnery devices | M32 periscope with active-IR channel | M32E1 peri- scope with passive night channel | M32E1 peri- scope with pas- sive night channel | M50 periscope with passive night channel | M35E1 peri- scope with passive night channel, AN/VSG-2 thermal- imaging sight on thermal version | M35E1 peri- scope with AN/VSG-2 thermal- imaging channel |
| | M13A2 computer | M13A2 computer | M13A2 computer | M19 electronic computer | M21 electronic solid-state computer | M21 electronic solid-state computer |
| | M10A1 ballis- tic drive | M10A5 ballis- tic drive | M10A5 ballis- tic drive | | M10A3 ballis- tic drive | M10A3 ballis- tic drive |
| | M105D coaxial telescope | M105D coaxial telescope | M105D coaxial telescope | M126 coaxial telescope | M105D coaxial telescope | M105D coaxial telescope |
| | AN/VSS-1 searchlight | AN/VSS-1 searchlight | AN/VSS-1 searchlight | AN/VSS-1 searchlight | AN/VSS-3 searchlight | AN/VSS-3 searchlight |
| Commander's devices | M19 cupola | M19 cupola | M19 cupola | Stabilized cupola | M19 cupola | M19 cupola |
| | M17A1 coincidence rangefinder | M17A1 coincidence rangefinder | M17C coincidence rangefinder | AN/VVS-1 ruby laser rangefinder | AN/VVG-2 ruby laser rangefinder | AN/VVG-2 ruby laser rangefinder |
| | M36 periscope with active-IR night channel | M36E1 peri- scope with pas- sive night channel | M36E1 peri- scope with pas- sive night channel | M51 periscope with passive night channel | M36E1 peri- scope with pas- sive night channel | M36E1 peri- scope with pas- sive night channel |
| Gun drive | Nonstabilized electrohy- draulic system | Nonstabilized electrohydrau- lic system | Stabilized elec- trohydraulic system | Stabilized elec- trohydraulic system linking gun and cupola | Stabilized elec- trohydraulic system | Stabilized elec- trohydraulic system |
| Other weapons | 7.62-mm M73 coaxial machinegun | 7.62-mm M73, M219, or M240 coaxial machineguns | 7.62-mm M73, M219, or M240 coaxial machineguns | 7.62-mm M219 coaxial machineguns | 7.62-mm M240 coaxial machineguns | 7.62-mm M240 coaxial machineguns |
| | 12.7-mm M85 AA machine- gun (all M60s) | | | | | |



Table 14
M1 Weapons and Fire-Control Systems

| | |
|--------------------|---|
| Main gun | 105-mm M68 until mid-1980s 120-mm Rheinmetall smoothbore XM256 after 1984 |
| Gunnery devices | Gunner's primary sight (GPS) contains Nd:YAG laser-rangefinder and AN/VSG thermal-imaging channel, interfaced with electronic digital computer Gunner's auxiliary sight (Kollmorgen 939 coaxial telescope) |
| Commander's sights | Commander's weapon station sight with commander's GPS extension AA gun sight |
| Gun drive | Stabilized electrohydraulic drive elevation slaved to GPS mirror |
| Other weapons | 7.62-mm M240 coaxial machinegun 7.62-mm M240 loader's machinegun 12.7-mm M2-HB commander's AA gun M239 smoke grenade launchers |

Exported M48 Tanks. Most of the M48s in foreign armies are M48A3s or M48A5s. Many are at least being upgraded with 105-mm guns. Conversion kits are readily available from the United States to fully upgrade older M48s to M48A5 standards. West German M48A2GA2s and Israeli M48A3s are equivalent to US M48A5s.

Israeli M48A3s were used in the 1973 war. These tanks, now upgraded with externally applied armor blocks, were used in the invasion of Lebanon in June 1982.

M60 and M1

The fire-control developments that began with the M48 continued through the M60 tanks, culminating in the M60A3 and M1 fire-control systems. Early M60s had 105-mm guns aimed with the aid of analog electromechanical computers and nonstabilized gun drives; commanders read target ranges with coincidence rangefinders. The M60A3 has an analog electronic computer, stabilized gun drive, and laser

rangefinder. The M60A3 and M1 fire-control systems use different devices but work similarly and use the same technology.

25X1

M60 tanks were introduced in 1960 as product-improved M48A2s. Some early M60s were sent to Iran and Israel.

25X1

The M60A1 was introduced in 1962. It was at first an M60 with an M140 gun mount. Beginning in 1966 the M13 series of electromechanical computers were replaced by M16-series electronic computers. The next major improvement was the fitting of gun-stabilizing feedback circuits in the M60A1 gun drive, starting in 1972. The tanks were then known as M60A1-AOS (add-on stabilizer) tanks. These were the first operational US tanks with the capability to fire on the move. The next fire-control improvement was the development of an image intensifier by 1977 to provide the gunner's and commander's sights with passive night channels. Tanks with the passive night channels were called the M60A1-PASSIVE.

25X1

The first M60A3s were M60A1s retrofitted with ruby laser rangefinders (AN/VVG-2s) for the commanders; M21 solid-state, electronic, analog computers; heavier duty gun drive motors; new coaxial machine-guns (M240, manufactured by Fabrique Nacional as the MAG-58); and new smoke grenade launchers (M239).

25X1

Numerous M60 tanks are in service in foreign armies, particularly in the Middle East. Most of the clients in the Middle East are buying conversion kits from the United States to fully upgrade their M60s to M60A3s.

25X1

Since late 1978, the passive night-vision channels in the US M60A3 gunner's sights have been replaced by AN/VSG-2 thermal-imaging systems made by the Hughes Aircraft Company. These are the latest M60 versions and are known as the M60A3-TTS (tank thermal sight).

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The M60A2 was a missile-firing version of the M60. M60A2s had 152-mm tubes that fired munitions and also launched Shillelagh ATGMs. M60A2s entered service in 1974; 526 were deployed in the US Army but are now being withdrawn. Sights, computers, and stabilizers on M60A2s are different from those on the later M60A1s and M60A3s. The M60A2 had several stabilized platforms. The gunner's periscope and commander's cupola were self-stabilized. The full turret was azimuth stabilized. All guns on the tank, including the AA machinegun, were linked to the same elevation stabilization reference. The M60A2 could not fire its missiles on the move because of missile-guidance problems.

25X1

The main difference between the fire-control systems of the M1 and M60A3-TTS is the way they are packaged. Both tanks use laser rangefinders; the rangefinders are a ruby laser operated by the commander in the M60A3 and an Nd:YAG laser operated by the gunner in the M1. Both tanks have thermal-imaging channels in the gunner's sight; the thermal channels are an add-on feature in the M60A3, but an integral part of the M1. Both tanks use electronic computers: the M60A3's is analog and the M1's is digital. The M60A3 computer automatically receives target range, ammunition type, wind-speed, and air temperature in its ballistic solution, whereas the M1 computer also automatically has a traverse-rate input to compute lead angles. Finally, the M60A3 gunner's sight follows the gun in elevation, but the gunner's sight for the M1 is self-stabilized and the gun follows the sight.

25X1

Secret

West Germany

West Germany designed the Leopard and TAM series of tanks and has begun the Kampfpanzer III project to design and build a new tank for the 1990s. Four versions of the Leopard I are in service with the West German Army. Other Leopard I variants are in service in other NATO armies. The Leopard II, considered to be as advanced as the US M1 Abrams tank, is entering service in the Dutch and West German Armies. Argentina is producing the TAM (Tanque Argentina Mediano or Argentine medium tank) for the Argentine Army under a license from the West German firm Thyssen-Henschel. Italy is producing the OF-40 tank, whose design was heavily influenced by that of the Leopard I, for export. [redacted]

Leopard I

From 1965 to 1977, West Germany produced 2,437 Leopard I tanks in six lots for its army. Although production for domestic use ended in 1977, production for export lasted until 1980. Germany produced 1,070 more tanks for foreign clients. In 1981 Germany resumed Leopard I production for export to Greece and Turkey. The Krauss-Maffei Company in Munich has built all of the Leopards except 75 built by Krupp and 720 built under license by Italy. [redacted]

The first 1,845 Leopard I's built for West Germany (lots 1 through 4) are now designated Leopard IA1A1s because of two improvement programs in the mid-1970s. The first improvement included retrofitting stabilizing equipment to the gun drives and thermal sleeves to the gun barrels. The improved tanks were called Leopard IA1s. The second improvement was the addition of spaced-armor plates to the Leopard IA1 turrets, resulting in the designation Leopard IA1A1. The originally manufactured turrets are made of cast steel. In the fifth German Army lot, 232 tanks were fitted with stronger cast-steel turrets (Leopard IA2s), and 110 tanks were fitted with all-welded, spaced-armor turrets (Leopard IA3s). The fire-control systems of the Leopard I, IA1, IA1A1, IA2, and IA3 tanks are similar. [redacted]

The sixth and last German Army lot consisted of 250 Leopard IA4s, with welded turrets and different fire-control systems. [redacted]

All Leopard I tanks have 105-mm British-designed L7 rifled main guns made by the West German firm Rheinmetall under license. The Leopard I tanks of the German Army usually carry two Rheinmetall 7.62-mm MG3 machineguns. One machinegun is mounted coaxially left of the main gun. It is controlled by the fire-control system and can be fired electrically by the gunner or mechanically by the loader. The other machinegun is for antiaircraft fire and is mounted at the loader's or commander's hatch. Four 77-mm grenade launchers made by Wegmann are on each side at the rear of the turret. [redacted]

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Leopards I, IA1, IA1A1, IA2, and IA3. The commander uses a Steinheil-Lear-Siegle TRP-2A panoramic periscope for target acquisition. The TRP-2A optics are monocular with zoom magnification from 4 to 20 power. The periscope mounting can traverse 360 degrees independently of the turret. If the commander sights a target, he can override the gunner's control of the turret-traverse drive and swing the gun toward the target. A flexshaft counterrotates the commander's periscope by an amount equal to the turret traverse angle in the override mode, enabling the periscope to remain on the target azimuth while the turret traverses. [redacted]

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The commander can override the gunner's fire control and use the TRP-2A to aim the gun after the periscope is locked in the 12 o'clock position on the turret. The viewing mirror of the periscope can be linked to the gun in elevation through an electric drive. The periscopic view can follow the gun to its maximum elevation. [redacted]

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The gun is usually aimed with a coincidence/stereoscopic rangefinder linked to the gun in elevation through ballistic cams. The rangefinder is a 16-power Zeiss TEM-2A with a 1.72-meter ranging base. The rangefinder can measure from 400 to 15,000 meters. It contains an analog ballistic computer consisting of two cams—one for an APDS round and the

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Table 15
Leopard I Weapons and Fire-Control Systems

| | Leopard IA1 Leopard IA1A1 | Leopard IA2 | Leopard IA3 | Leopard IA4 |
|---------------------------|--|--|--|--|
| Main gun | 105-mm L7A3 | 105-mm L7A3 | 105-mm L7A3 | 105-mm L7A3 |
| Gunnery devices | TEM-2A day sight with coincidence/stereoscopic rangefinder | TEM-2A day sight with coincidence/stereoscopic rangefinder | TEM-2A day sight with coincidence/stereoscopic rangefinder | EMES-12A1 day sight with stereoscopic rangefinder |
| | | | | FLER-H, -HG, or -M analog electronic computer |
| | TZF-1A coaxial telescope | TZF-1A coaxial telescope | TZF-1A coaxial telescope | TZF-1A coaxial telescope |
| | B171-IV IR sight or retrofitted PZB-200 LLLTV | B171-IV IR sight or retrofitted PZB-200 LLLTV | B171-IV IR sight or retrofitted PZB-200 LLLTV | PZB-200 LLLTV |
| Commander's sights | TRP-2A panoramic day periscope | TRP-2A panoramic day periscope | TRP-2A panoramic day periscope | PERI-R-12 panoramic periscope with passive night channel |
| IR source | XSW-30-U xenon white/IR searchlight required | XSW-30-U xenon white/IR searchlight required | XSW-30-U xenon white/IR searchlight required | Optional XSW-30-U |
| Gun drive | Retrofitted, stabilized electrohydraulic | Stabilized electrohydraulic | Stabilized electrohydraulic | Stabilized electrohydraulic |
| Other weapons | 7.62-mm MG3 coaxial and AA machineguns | 7.62-mm MG3 coaxial and AA machineguns | 7.62-mm MG3 coaxial and AA machineguns | 7.62-mm MG3 coaxial and AA machineguns |
| | Eight 77-mm grenade launchers | Eight 77-mm grenade launchers | Eight 77-mm grenade launchers | Eight 77-mm grenade launchers |

other for a HEAT round. The cams can be used only for ranges between 400 and 3,800 meters. The cams displace a reticle in the rangefinder. The gunner elevates the gun until the reticles are back on target and then fires. [redacted]

Alternatively, the gunner can use a Zeiss TZF-1A, 8-power, articulated telescope mounted on the right side of the gun. The telescope has a reticle indexed with aiming marks for the APDS and HEAT rounds. The TZF-1A is on all Leopard I tanks. [redacted]

The gun drive, built by Feinmechanische Werke, is an electrohydraulic mechanism with gyroscopically controlled stabilizing circuits for traverse and elevation. The Leopard I tanks built before 1971 had electrohydraulic traverse and elevation motors but no stabilizing provisions. Those built after 1971 were fitted with

stabilizing circuits, and the earlier tanks were retrofitted to give them the same stabilization capability. The turret follows a traverse-reference gyroscope, and the gun follows an elevation-reference gyroscope. The TEM-2A rangefinder, TZF-1A telescope, and TRP-2A periscope all follow the gun elevation because they are slave linked to the gun. [redacted]

The Leopard I traverse motor can rotate the turret 360 degrees in 16 seconds, giving an average maximum traverse rate of 22.5 degrees per second. The traverse rate decreases to about 15 degrees per second when the stabilizer is operating. The minimum traverse rate is 0.03 degree per second. The stabilized elevation drive can elevate the gun at a maximum rate of 5.4 degrees per second. [redacted]

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For night firing, the commander can replace the TRP-2A periscope with an Eltro B171-series passive image intensifier. An XSW-30-U white/IR searchlight by AEG-Telefunken can be mounted externally over the gun to illuminate targets for the gunner. The searchlight is elevated with the gun. The searchlight contains a xenon tube that emits visible white light and near-infrared light. It can be fitted with a filter to block the visible light, leaving an invisible near-infrared beam. The commander can acquire and designate targets at night with the near-infrared beam, but the gunner needs the visible light from the searchlight to see through the rangefinding sight. When not in use, the searchlight is carried in a stowage box on the rear of the turret. []

AEG-Telefunken offers a passive low-light-level television (LLLTV) monitor, designated the PZB-200, which is mounted on some German Army Leopard I tanks. The monitor consists of a TV camera, mounted over the gun in place of the searchlight, and TV screens for the gunner and commander. []

Leopard IA4. The Leopard IA4 fire-control system differs significantly from those of earlier Leopards. The commander's periscope and gunner's rangefinding sight are different, and an electronic ballistic computer is used to displace the aiming reticles. []

The commander's periscope is a Zeiss PERI-R-12 panoramic periscope with a combined day and night capability. The night channel contains a passive image intensifier. The periscope mounting traverses 360 degrees independently of the turret, and the mirror can be elevated 60 degrees. []

The rangefinder is a Zeiss EMES-12A1 stereoscopic rangefinder with a 1.72-meter rangefinding base and two magnifications—8 and 16 power. The EMES-12A1 can range on objects from 400 to 15,000 meters away. []

The computer is an AEG-Telefunken FLER-series hybrid electronic computer. It calculates superelevation angles for targets between 400 and 3,000 meters in range. The only ballistic inputs to the computer are a range reading from the EMES-12A1 sight and the ammunition selection []

The Leopard IA4 has the same stabilized gun drive as the earlier Leopards. The sights are slave linked to follow the gun in the same manner as the earlier Leopard sights. []

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The Leopard IA4 follows the same night combat procedure as the earlier Leopards in the German Army. The only difference in night capability is that the night channel is built into the Leopard IA4 commander's sight and does not have to be interchanged with a separate day sight. The gunner needs a searchlight for night firing. Leopard IA4s also can use the PZB-200 LLLTV system. []

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Future Fire-Control Retrofit of German-Army Leopard I's.

West Germany is planning a fire-control retrofit for its Leopard I tanks beginning about 1986. The requirements call for systems using laser rangefinders and digital-electronic ballistic computers. The contractors who will most likely compete for the new system are AEG-Telefunken and Zeiss. []

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Exported Leopard I's With SABCA Fire Control.

Australia, Belgium, and Canada have Leopard I tanks fitted with gunnery sights and ballistic computers made by the Belgian firm SABCA. The Australian and Canadian tanks were produced with the SABCA devices, whereas the Belgian tanks were retrofitted with them. The SABCA devices are a laser rangefinder (using a ruby laser on older models and an Nd:YAG laser on newer ones), other automatic sensors, and an electronic computer. The SABCA devices are all analog. The SABCA systems were originally produced under license from the US Hughes Aircraft Company and marketed as the Cobelta systems. The left rangefinding optic is not used on SABCA-equipped Leopards because the laser rangefinder requires only one optic and is mounted under the right optic. The computer accepts inputs from the laser rangefinder and other automatic sensors. Data from the automatic sensors include air temperature, air pressure, ammunition-charge temperature, gun wear, crosswind, vehicle cant, and turret traverse rate. The computer calculates both superelevation and traverse-offset angles to aim the gun. The traverse offset

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includes a lead angle estimate for moving targets based on the traverse-rate reading. The computer drives a system of mirrors in the gunsight to shift the target image off center by an amount equal but opposite to the superelevation vertically and the azimuth offset horizontally. The gunner traverses the turret and elevates the gun until the target image is centered and then fires. [redacted]

Belgium received 334 unmodified Leopard I tanks from 1968 to 1971. Initially, these tanks differed from those of the German Army in that they were equipped with Belgian Fabrique Nacional machineguns instead of Rheinmetall machineguns. The Belgian tanks were retrofitted with the same Feinmechanische Werke stabilizing circuits in the gun drives as the German Leopard I's and with the SABCA fire-control devices. [redacted]

Australia received 90 Leopard IA3s with the SABCA devices between 1976 and 1978. The Australian Leopards are designated the AS1s. [redacted]

Canada received 114 Leopard IA3s with the SABCA devices and PZB-200 LLLTV systems in 1978 and 1979 to replace its Centurion tanks. Canada designated its Leopards the C1 tanks. These Leopards were the first to be produced with the PZB-200 LLLTV for night firing. They have a white-light searchlight mounted in the unused left rangefinding optic. In 1981 a report from a US attache indicated Canadian interest in fitting muzzle-reference systems and improved thermal sleeves to the C1 guns to improve their accuracy and adding thermal-imaging sights. We do not know if Canada will procure any of these items. [redacted]

Other Exported Leopard I's. Italy received 200 Leopard I tanks in 1971 and 1972. An Italian consortium headed by the firm OTO-Melara produced 720 Leopard I's under license from 1974 to 1981-82. These tanks were built or retrofitted to the German Leopard IA1A1 specifications. [redacted]

The Netherlands received 468 Leopard I's, produced from October 1969 to March 1972. The Dutch Leopard I armament and fire-control systems were initially the same as the original-model Leopard I's for the

West German Army, except that they have Dutch-made smoke-grenade launchers. The tanks were retrofitted with gun-drive stabilizers similar to those of the German Leopard I's. The Rheinmetall MG-3 machineguns were replaced by Fabrique Nacional 7.62-mm machineguns in the coaxial mounts and Browning 12.7-mm M2-HB machineguns on top of the turret. [redacted]

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Norway received 78 Leopard I's produced from January to July of 1971. The Norwegian Leopard fire-control systems are the original Leopard I systems, without gun-drive stabilizers. [redacted]

25X1

Denmark received 120 Leopard IA3 tanks from 1976 to 1978, designating them the DK. These tanks have the same fire-control systems as the West German Army Leopard IA3s. [redacted]

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Greece has ordered 106 Leopard IA4s, scheduled for delivery in 1983-84. Turkey also has ordered between 77 and 183 Leopard 1A3s, to be built with a Zeiss system reported as the AFZ system, for delivery in the same time frame. [redacted]

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Leopard II

The Leopard II tank (see figure 6) is considered a new-generation tank equivalent to the UK Challenger and US M-1 tanks. The Leopard II is protected by advanced armor. Production and delivery of Leopard II tanks to the West German Army began in 1979. Planned production for the German Army probably will continue until 1986 and total 1,800 tanks. The Netherlands has ordered 445 Leopard IIs for delivery from 1982 to 1986. Krauss-Maffei will build 990 German and 278 Dutch Leopard IIs, and Krupp will build 810 German and 167 Dutch Leopard IIs. [redacted]

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The main gun of the Leopard II has a smoothbore tube 44 calibers (5.3 meters) long, vertically sliding wedge breechblock, bore evacuator, and thermal sleeve; it does not have a muzzle brake. The gun is fired electrically or with a manual electric-impulse generator and can fire up to nine rounds per minute. [redacted]

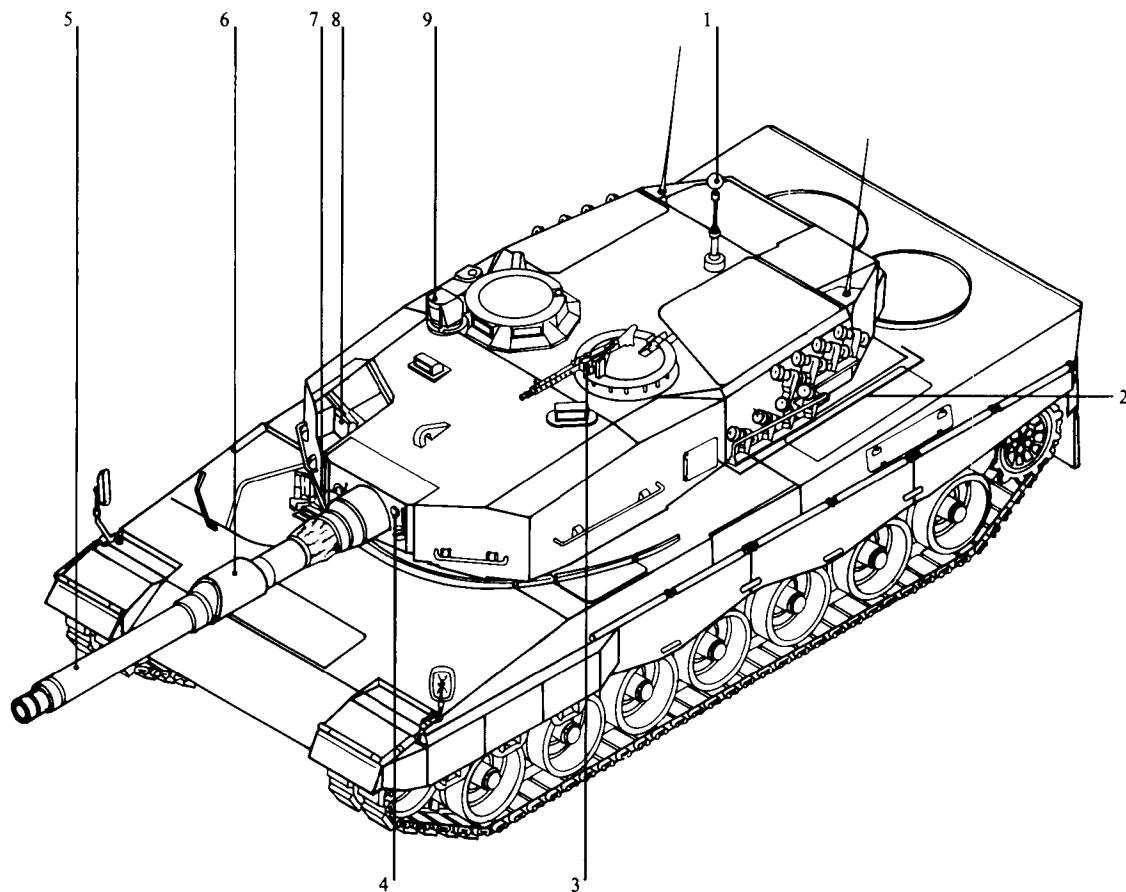
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Figure 6
West German Leopard II



1. Crosswind sensor for fire-control system
2. 77-mm grenade launchers
3. 7.62-mm MG3-A1 machinegun
4. 7.62-mm MG3-A1 coaxial machinegun
5. 120-mm smoothbore main gun
6. Bore evacuator
7. FERO-Z-18 coaxial telescope
8. EMES-15 gunsight, laser rangefinder, and thermal-imaging channel
9. PERI-R-17 day/night panoramic periscope

Secret

Table 16
Leopard II Weapons and
Fire-Control Systems

| | West German Leopard II | Dutch Leopard II |
|-------------------|---|---|
| Main gun | 120-mm Rheinmetall smoothbore | 120-mm Rheinmetall smoothbore |
| Gunnery devices | EMES-15 primary sight with Nd:YAG laser rangefinder feeding FLT-2 hybrid computer | EMES-15 sight |
| | FERO-Z-18 coaxial telescope | FERO-Z-18 |
| | PZB-200 LLLTV in lieu of thermal- imaging channel inside EMES-15 | Different night vision |
| Commander's sight | PERI-R-17 day/night panoramic telescope | PERI-R-17 |
| Gun drive | WNA-H22 stabilized electrohydraulic | Probably WNA-H22 |
| Other weapons | 7.62-mm MG3-A1 coaxial and AA machineguns | 7.62-mm MAG-58 coaxial and AA machineguns |
| | 16 Wegmann 77-mm smoke grenade launchers | Dutch-made grenade launchers |

The rounds for the main gun are projectiles fixed to combustible charge cases with noncombustible steel bases. Either the DM-13 APFSDS-T kinetic energy projectile or the DM-12 multipurpose shaped-charge projectile can be used.

The Leopard II fire-control system was initially required to consist of devices developed from earlier Leopard I devices to provide commonality in the Leopard I and II systems. Early Leopard II prototypes had Leopard-I-type fire-control systems. However, as a result of the decision to use advanced armor on the Leopard II, the design of the turret, and subsequently the fire-control system, was significantly changed.

The Leopard II fire-control system is integrated and controlled by a computer designated the FLT-2 built by Krupp-Atlas Elektronik. The tank commander can select one of at least 12 modes of operation. Depending on the mode, the gun can be aimed with the commander's sight (PERI-R-17), gunner's sight (EMES-15), or the coaxial telescope (FERO-Z-18). In the more automated modes, the computer stabilizes the PERI-R-17 and EMES-15 sightlines in elevation, and the gun elevation is stabilized by following the sightlines.

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The PERI-R-17, built by Zeiss, is the commander's primary sight. It can traverse 360 degrees independently of the turret, and its line-of-sight elevation exceeds the elevation limits of the gun. The sight contains a passive, image-intensifying, night-vision channel.

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The EMES-15, built by Krupp-Atlas Elektronik, contains an Nd:YAG laser rangefinder. The EMES-15 is designed to contain a thermal-imaging channel, abbreviated WBG in German, that operates passively in the 8- to 14-micron spectrum. The WBG sensors are being built under license from Texas Instruments, but as of October 1981 none had been installed because of unspecified production problems.

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Most Leopard II tanks have a Telefunken PZB-200 LLLTV system to provide passive night aiming for the gunner. The LLLTV system will be used until the problems with the WBG sensors are solved.

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In manual operating modes, the gunner can aim the gun using the FERO-Z-18 coaxial telescope on the gun. The telescope is built by Leitz.

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The computer automatically accepts inputs from the laser rangefinder, the gun-elevation and turret-traverse gyroscopes, a crosswind sensor, and a tank-speed tachometer. When the PERI-R-17 sight or the turret are traversing to follow a moving target, their traverse rates are automatically fed into the computer. The ammunition type, air pressure, air temperature, ammunition-charge temperature, and gun-wear

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estimate are manually entered. The range is displayed to the gunner for verification. The computer continuously calculates superelevation and traverse-offset angles for gunnery and correction angles to stabilize the turret, gun, and sights. A coincidence circuit in the computer permits firing only when the gun is within a specified deviation from the correct firing elevation. The superelevation and traverse-offset signals are electronically corrected for turret cant angle after leaving the computer, but before being applied to the gun drive.

The computer has hybrid circuitry consisting of discrete, small- and medium-scale integrated components. We do not know the memory type or size.

The Leopard II gun drive is a WNA-H22 stabilized, electrohydraulic system developed jointly by AEG-Telefunken, Feinmechanische Werke, and Honeywell-Europe. The system has enough power to traverse the 16-ton turret at 40 degrees per second and to elevate the gun at 10 degrees per second. The drive can elevate the gun to 20 degrees and lower it to -9 degrees.

Kampfpanzer III

West Germany has undertaken the Kampfpanzer III project to design a tank for the 1990s. The government is considering three new designs: a turreted design by Krauss Maffei and Krupp, based on the Leopard II; a turretless, one-gun design by Krupp, Thyssen-Henschel, and Gesellschaft fur System Technik; and a turretless, two-gun design by Krupp. The fire-control system for the new tank will depend on the tank design selected for development and the technology available.

Argentine/German TAM Tanks

The TAM (Tank-Argentina-Medium) is a tank designed by the West German firm Thyssen-Henschel in the mid-1970s for Argentine production. Thyssen-Henschel delivered three prototypes to Argentina by 1977. The prototypes are commonly called the TAM 1, 2, and 3. Argentine production began by 1980, and possibly as early as 1978. Argentina intends to build

Table 17
TAM and TH-301 Weapons and Fire-Control Systems

| | Argentine TAM Prototypes | TH-301 |
|-------------------|-------------------------------------|---|
| Main gun | 105-mm L7A3 | 105-mm Rheinmetall Rh-105-30 |
| Gunnery devices | TZF coaxial telescope | Probably TZF coaxial telescope Reported laser rangefinder in EMES-12 sight |
| Gun drive | Stabilized electrohydraulic | Stabilized electrohydraulic |
| Commander's sight | TRP-2A panoramic periscope | PERI-R-12 panoramic periscope with passive night channel |
| | Unconfirmed coincidence rangefinder | |
| Other weapons | 7.62-mm coaxial and AA machineguns | Not finalized |
| | Eight Wegmann grenade launchers | Probably Wegmann grenade launchers |

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at least 200 TAM tanks to replace its US M4 Sherman tanks. It also plans to build TAMs for export, and arms trade representatives are vigorously seeking orders from a number of countries.

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US attaches report that TAM production has been unsteady and has encountered many problems. The problems were once reported to be so severe that Argentina might consider buying the UK Vickers Mark 3 instead.

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By 1979 Thyssen-Henschel had built a fourth prototype of the TAM with a 105-mm gun and designed a 120-mm version. The fourth prototype, originally called the TAM 4 in the press, has been redesignated the TH-301. Thyssen-Henschel is offering it for export and has possibly received an order from Malaysia.

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Most of the TAM components, including the main gun but not the fire-control devices, are made in Argentina. The main gun is described as the British L7A3 in various weapons trade publications but may be a Rheinmetall copy of the L7 design, the Rh-105-30. The TAM guns are built and integrated into the fire-control system at the turret production plant in Rio Tercero. The TAMs have 7.62-mm coaxial machineguns designed by the Belgian firm Fabrique Nacional and built under license in Argentina. These machineguns also are mounted on top of some TAM turrets for AA defense. [redacted]

The first TAM production models used fire-control devices imported from Germany. Several of the fire-control devices for the TAM are those used on the German Army's Leopard IA1A1, IA2, and IA3 tanks. These include the commander's sights (Steinheil TRP-2A), coaxial telescopes (Zeiss TZF-series), and stabilized gun drives. [redacted]

We are not sure of the rangefinding or ballistic computing methods in the most recently produced TAM tanks. The Argentine press reported that the TAM has a coincidence rangefinder operated by the commander. However, the TRP-2A commander's sight is not a coincidence rangefinder. A US attache reported in 1979 that the TAM has a laser rangefinder operated by the gunner, a stadiametric-rangefinding reticle for the commander, and that the Argentines wanted a comparable laser rangefinder for the commander. The reported inconsistencies could be a result of Argentine indecision in the final model designs or the production problems mentioned by several US attachés. [redacted]

We are not sure of the night-firing capability of the TAM. If its fire-control system is a close copy of the Leopard I through IA3 systems, then the TAM night-vision equipment probably consists of a passive night sight that is interchangeable with the commander's sight and a white-light searchlight to aid the gunner. The attache report in 1979 stated that night-vision devices would be added to TAMs later in production but did not specify the devices. In 1980 a US attache reported that the Italian firm Aeritalia had agreed to license one of its passive image intensifiers for Argentine manufacture as part of the TAM project. An [redacted]

attache report in 1983, however, stated that the Dutch firm Odelft granted a license for Argentine production of night-vision devices for the TAM. [redacted]

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AEG-Telefunken will probably offer its PZB-200 LLLTV system for the TAM. A smaller LLLTV system exhibited by the Argentine Armed Forces Institute of Science and Technology Research also may be adapted for TAM installation. [redacted]

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TH-301. The TH-301 has a fire-control system similar or identical to that of the Leopard IA4 and the same commander's sight (PERI-R-12), electronic ballistic computer (FLER-HG), and stabilized gun drive. The TH-301 gunner's sight is a telescope that contains a laser rangefinder. A Telefunken PZB-200 LLLTV system can be mounted on the TH-301 for night firing. [redacted]

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Italian OF-30 and OF-40 Tanks

The Italian firms OTO-Melara and Fiat offer the 40-ton OF-40 and OF-40 Mark 2 tanks for export, drawing on experience and designs gained during OTO-Melara's licensed production of the German Leopard I in the 1970s. At least 20 OF-40s were delivered to Dubayy beginning in 1981. In April 1982, OTO-Melara was attempting to sell OF-40s to Malaysia. The OF-40 Mark 2 program is still in a testing stage. [redacted]

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The OF-40 fire-control system, except the gun drives, is designed and built by the Italian firm Oficine Galileo. Advertisements given to the Malaysians by the Italians imply that the existing OF-40 tanks probably have the version of the system designated the OG-14LR. Oficine Galileo offers a more elaborate version of the system designated the OG-14LS. [redacted]

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Table 18
OF-40 Weapons and OG-14LR
Fire-Control System

| | |
|-------------------|---|
| Main gun | 105-mm OTO-Melara rifled gun |
| Gunnery devices | C125 periscopic sight with Nd:YAG laser rangefinder and passive night appendage |
| | Coaxial telescope |
| | Unspecified fire-control computer |
| Gun drive | Nonstabilized electrohydraulic |
| Commander's sight | SFIM VS-580 panoramic periscope |
| Other weapons | 7.62-mm coaxial machinegun |
| | 7.62-mm AA machinegun |
| | Eight grenade launchers |

also aim with a coaxial telescope made by the Italian firm Aeritalia that contains aiming scales for the OF-40 ammunition.

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OF-40 With OG-14LR Fire-Control System. The main gun of the OF-40 fires standard NATO rounds designed for the British L7 gun. The Italian gun is similar to the L7, but it has a vertically sliding breechblock. Brochures on the OF-40 given to Malaysia state that the tanks are provided with brackets for 7.62-mm coaxial and AA machineguns. A buyer can install 7.62-mm machineguns common to NATO tanks such as the German Rheinmetall MG3s or Belgian Fabrique Nacional MAG-58s.

The OF-40 commander's sight is the VS-580 made by the French firm SFIM. The VS-580 is an 8-power monocular periscope that can be traversed independently of the turret. The OF-40 does not have a rotating cupola. The periscope contains aiming scales for the OF-40 rounds and a stadiametric-rangefinding scale and can be linked to the gun. The commander can override the gunner's control of the fire-control system, and aim the gun with the periscope. SFIM offers the periscope with a passive night channel that has a second-generation image intensifier. The periscope is also available with a gyroscope to stabilize the sight mirror for target acquisition while on the move, but the gun is not stabilized.

The OF-40 gunner aims with a C125 binocular periscopic sight. The sight contains a laser rangefinder made by the Italian firm Selenia (probably the VAQ-33 Nd:YAG laser rangefinder) that can measure ranges from 400 to 6,000 meters. The gunner can

A variety of weapons trade publications list the OF-40 as having a ballistic computer. Available descriptions of the OG-14 fire-control system are imprecise about the technology and operation of the computer. The OG-14LR system probably uses an electronic analog computer. The computer accepts inputs from at least the laser rangefinder, a gun-elevation sensor, and the ammunition selector and calculates superelevation angles. OTO-Melara brochures specify that superelevation angles are automatically transferred with a ballistic drive system. We presume that the angles are transmitted from the computer by mechanical linkage or electrical signal to the C125 sight and possibly the commander's periscope. The angle signals deflect a reticle or the target image. The gunner elevates the gun until the reticle and target image are together and then fires.

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The OG-14LRS is described in weapons trade publications as a stabilized OG-14LR system.

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OF-40 Mark 2. The first OF-40 Mark 2 prototype was tested in August 1982. An arms trade magazine described the tank as an OF-40 with the OG-14LR fire-control system and a stabilized gun drive built by AEG-Telefunken. Published photographs of the tank show an LLLTV mounted on the mantle. Presumably it is identical to one that has been advertised by Oficine Galileo, but we have no details on the integration of the LLLTV into the fire-control system.

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OG-14LS Fire-Control System. Judging from Oficine Galileo advertisements, the OG-14LS is the OG-14LR system with an elevation-stabilized gunner's sight, a digital computer, and several sensors for additional computer inputs. The new inputs are charge temperature, air temperature, air pressure, wind speed, humidity, gun wear, tank ground speed, and turret traverse rate. Oficine Galileo also offers an optical thermal-imaging sight for the OG-14LS.

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Appendix A**Glossary**

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| AA | Antiaircraft. |
| Abrams | M1 tank, newest US tank. |
| ACRA | French ATGM of early 1970s. |
| Active IR | Night-vision technology using near-infrared lights and sights. |
| AEG-Telefunken | West German firm making fire-control components. |
| Aeritalia | Italian firm offering night-vision sights for Argentine TAM. |
| Amplidyne | DC motor-generator set connected to serve as power amplifier. |
| AMX-30 | Current French-designed tank. |
| AMX-32 | French-designed tank being offered for export. |
| AOS | US acronym for add-on stabilizer in M60 tanks. |
| AP | Armor-piercing ammunition. |
| APC | Armor-piercing capped ammunition. |
| APDS | Armor-piercing, discarding-sabot ammunition. |
| APFSDS | Armor-piercing, fin-stabilized, discarding-sabot ammunition. |
| APFSDS-T | APFSDS ammunition with tracer. |
| ATGM | Antitank guided missile. |
| Atlas Elektronik | Subsidiary of West German firm Krupp, makes fire-control components. |
| Autoloader | Automatic loader for main tank gun. |
| Avimo | UK firm making optical tank sights and laser rangefinders. |
| Azimuth | Direction in plane of horizon, usually measured from due north. |
| Ballistic inputs | Quantities that influence ballistic trajectories (for example, range, windspeed, and air density). |
| Baotou | Chinese tank production plant. |

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| Barr and Stroud | UK firm making optical tank sights and laser rangefinders. |
| Bernardini | Brazilian firm making armored vehicles. |
| BMY | Bowen-McLaughlin-York; US artillery firm that built tank-rebuilding plant in Iran. |
| Bofors | Swedish firm making armored vehicles. |
| Boresight | Line-of-sight through barrel of gun. |
| Browning | US firm making .50-caliber (12.7-mm) machineguns. |
| Cadillac Gage | US firm making stabilized gun drives. |
| Caliber | <ol style="list-style-type: none">1. Internal diameter of gun barrel in inches or millimeters.2. Length of gun barrel expressed as multiple of its caliber. |
| Cant | Sideways tilt of a tank. |
| Carl Stiftung Zeiss | West German firm making optical tank sights and fire-control systems. |
| Cascavel | Armored vehicle built by Brazilian firm Engesa. |
| Centurion | UK tanks built in the 1950s and 1960s. |
| Challenger | Latest UK tank design, intended for production in mid-1980s. |
| Chieftain | UK's current main battle tank. |
| CILAS | Compagnie Industrielle des Lasers; French firm making laser rangefinders. |
| Coaxial | Aimed along same axis as main gun. |
| Cockerill | Belgian firm making armament. |
| Coincidence rangefinder | Optical rangefinder based on slightly different viewing angles to an object seen from two different viewpoints. |
| Collimator | Optical device that provides uniform illumination within a sight. |
| Comet | UK tank built in 1940s. |
| COSTAC | Conduite de Tir Stabilisee Automatique pour Char; stabilized COTAC system. |
| COTAC | Conduite de Tir Automatique pour Char; series of fire-control components made by GIAT. |

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| Counterrotation | Cupola rotation opposite turret traverse; designed to keep cupola sight pointed at a target. |
| Daikin | Japanese firm making APFSDS ammunition. |
| Dalian | Chinese military academy. |
| Delta-D | Soviet tank device that compensates for changes in range. |
| DS | Discarding-sabot ammunition. |
| DShK | Degtyareva Shpagina Krupnokalibernyy; Soviet designator for 12.7-mm machinegun. |
| Elbit | Israeli firm making fire-control devices for Merkava tanks. |
| Electrohydraulic | Gun drive with hydraulic power components controlled by electric circuitry. |
| Electromechanical | Consisting of mixture of electric, electronic, and mechanical components. |
| Electro-optic | 1. Using quantum-effect interactions between optical and solid-state electronic devices. 2. Containing optical and electronic components. |
| Elevation | Angle measured upward from local horizon. |
| El-Op | Israeli firm making electro-optical devices. |
| Eltro | West German firm making night-vision equipment for tanks. |
| Engesa | Brazilian firm making armored vehicles. |
| EOS | Israeli designator for xenon searchlights on Merkava tanks. |
| Ericsson | L. M. Ericsson; Norwegian firm making laser rangefinders. |
| F | Fragmentation ammunition. |
| Fabrique Nacional | Belgian firm making machineguns used on many tanks. |
| Ferranti | UK firm making fire-control components. |
| Fiat | Italian automotive firm making the OF-40 tank with OTO-Melara. |
| FS | Fin-stabilized ammunition. |
| FWM | Feinmechanische Werke Mainz; West German firm making gun drives. |

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| GAS | US designator for gunner's auxiliary sight, coaxial telescope in M1 tank. |
| GCE | UK designator for gun control equipment. |
| GIAT | Groupement Industriel des Armements Terrestres; French firm making armored vehicles and their components. |
| GPS | US designation for gunner's primary sight in M1 tank. |
| Gun wear | Gun fatigue and erosion tending to reduce muzzle velocity. |
| Gyrotachometer | Gyroscopic device used to measure angle rate. |
| HE | High-explosive ammunition. |
| HEAT | High-explosive antitank ammunition. |
| HEI | High-explosive incendiary ammunition. |
| HESH | High-explosive squash-head ammunition. |
| Homogeneous armor | Solid steel armor. |
| Honeywell | US-based firm making gun drives in West Germany. |
| Hughes Aircraft | US firm making armament, electronics, optical tank sights, and laser rangefinders. |
| Hydropneumatic | Mixture of hydraulic and pneumatic mechanisms. |
| IFCS | Integrated Fire-Control System made by Marconi Space and Defence Systems Limited. |
| IR | Infrared; light radiation from 0.7 to tens of microns in wavelength. |
| Israeli Ordnance | Israeli firm assembling Merkava tanks. |
| Joanell | US firm making night-vision devices. |
| Joystick | Small stick that can be swiveled by hand in all directions to control tank machinery. |
| Jungner | Swedish firm making optical tank sights. |
| Khalid | Version of Chieftain tank built by ROF for Jordan. |
| Kobra | Possibly the name of Soviet T-64B's missile. |
| Kollmorgen | US firm making optical tank sights. |

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| Komatsu | Japanese firm making HEAT-FS ammunition. |
| Krauss-Maffei | German firm making armored vehicles. |
| Krupp | West German firm making armored vehicles and armament. |
| Laser rangefinder | Rangefinder based on time interval for laser pulse to reach a target and return. |
| Leitz | Ernst Leitz Wetzlar; West German firm making optical tank sights. |
| Leopard | Current West German tank line. |
| Leyland | UK automotive firm making armored vehicles. |
| LLLTV | Low-light-level television. |
| LSI | Large-scale integration (electronics). |
| Lucas | UK firm making gun drives. |
| Lyran | Swedish firm making illuminating rounds. |
| M1 | 1. Latest US tank. 2. Israeli-modified M4. |
| M4 | US Sherman tank, World War II-vintage tank. |
| M47 | US tank built in 1940s and 1950s. |
| M48 | US tank built in 1950s and 1960s; modified in 1970s. |
| M50 | Israeli-modified M4. |
| M51 | Israeli-modified M4. |
| M60 | US tank built in 1960s and 1970s, currently deployed. |
| M551 | M551 Sheridan, US armored reconnaissance vehicle. |
| Mak | Mak Maschinenbau, subsidiary of West German firm Krupp; makes armored vehicles. |
| Marconi Radar | UK firm making the SFCS-600 fire-control system. |
| Marconi Space and Defence | UK firm making the IFCS fire-control system. |
| Merkava | Israeli-designed and -produced tank. |

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| Metadyne | Electromechanical machine used for precise position control. |
| Meteor | Soviet designator for stabilized gun drive in T-62 tank. |
| Mitsubishi | Japanese firm making machinery. |
| MSI | Medium-scale integration (electronics). |
| Muzzle reference system | Measures deviation of muzzle boresight from indicated gun boresight. |
| Nd:glass | Neodymium:glass, popular laser crystal. |
| Nd:YAG | Neodymium:Yttrium-Aluminum-Garnet, popular laser crystal. |
| Near IR | Near infrared; infrared light with wavelengths of about 0.7 to 1.5 microns, near the visible wavelengths of 0.4 to 0.7 microns. |
| Nihon Tokushya Kinzoka | Japan Special Metal Co.; makes machineguns. |
| Nikon | Japanese firm making optical tank sights. |
| Nippon Kogaku | Nippon Electric; Japanese firm making laser rangefinders. |
| Nonhomogeneous armor | Armor that is not solid steel; could be ceramic, plastic, steel plate, or layered combinations of these in various spatial arrangements. |
| NORINCO | Northern Industrial Corporation; principal Chinese contact with Western firms. |
| NSV | Soviet 12.7-mm machinegun designator. |
| Oerlikon | Swiss firm making armament. |
| OF-40 | Italian-built tank being exported. |
| Oficine Galileo | Italian firm making fire-control components. |
| Oldelft | Dutch firm making night-vision sights. |
| Olifant | South African version of Centurion tank. |
| Optic-electronic | See electro-optic. |
| OTO-Melara | Italian firm making armored vehicles and armament. |
| Passive | Sight that does not require any manmade light source. |
| Pilkington | UK firm making night-vision devices. |

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| PIP | Product Improvement Program; US term for programmed changes in an armored vehicle design during production. |
| PKT | Pulemet Kalashnikov Tankovyy; Soviet 7.62-mm machinegun designator. |
| Polsten | Automatic cannon installed in early UK Centurion tanks. |
| Pz55 | UK-made Centurion tank in Swiss Army. |
| Pz57 | UK-made Centurion tank in Swiss Army. |
| Pz61 | Swiss-made tank built in 1960s. |
| Pz68 | Swiss-made tank built in 1970s. |
| RAPACE | French battle-surveillance radar; mounted on some AMX-30 tanks. |
| Rate gyroscope | Gyrotachometer. |
| Resolver | Electromechanical device that generates a signal indicating the mechanical angle; used for precise measurement of gun position. |
| Reticle | Pattern projected into gunsight eyepiece to aid rangefinding and aiming. |
| Retrofit | Installation of new equipment into a deployed armored vehicle that was not originally supplied with the vehicle. |
| Rheinmetall | West German firm making armament. |
| RISE | US acronym for reliability improved selected equipment on improved M60. |
| RMG | Ranging machinegun. |
| ROF | Royal Ordnance Factories; official UK arsenal making armored vehicles and armament. |
| ROKIT | Republic of Korea indigenous tank. |
| ROM | Read-only memory; electronic memory device. |
| Ruby laser | Laser based on chromium-doped aluminum oxide crystal (ruby). |
| SABCA | Societe Anonyme Belge de Constructions Aeronautiques; Belgian firm making fire-control systems. |
| Sabot | Split sheath that surrounds armor-piercing rounds, designed to carry round down gun bore upon firing and separate from round at muzzle. |
| SACLOS | Semiautomatic command to line-of-sight; ATGM guidance technique. |

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| SAMM | Societe d'Applications des Machines Motrices; French firm making gun drives. |
| Satory | Annual French arms show. |
| Selenia | Italian firm making laser rangefinders. |
| Servoamplifier | Signal amplifier in gun-drive control circuit. |
| Servomotor | Gun-drive motor that moves the turret or gun. |
| SFCS | Simplified fire-control system made by Marconi Radar. |
| SFIM | Societe de Fabrication d'Instruments de Mesure; French firm making optical and night-vision sights. |
| SGMT | Stankovy Goryunov Modernizovannyy Tankovyy; Soviet 7.62-mm machinegun designator. |
| S.H.L. | Possible Israeli designator for Merkava gun drive. |
| Sheridan | M551 Sheridan, US armored reconnaissance vehicle. |
| Sherman | M4 Sherman, World War II US tank. |
| SLS | Possible Israeli designator for Merkava gunsight. |
| Sopelem | Societe d'Optique Precision Electronique et Mecanique; French firm making optical sights and night-vision equipment. |
| SSI | Small-scale integration (electronics). |
| Stabilize | To hold turret on a steady inertial azimuth and gun on a steady inertial elevation while the tank is moving. |
| Stabilizer | Stabilized gun drive or a set of circuits that enable the gun drive to stabilize. |
| Stadiametric rangefinder | Rangefinder based on angular size of an object at varying distances |
| Steinheil Lear Siegler | West German firm making optical tank sights. |
| Stereoscopic rangefinder | Rangefinder based on slightly different images of an object seen from two viewpoints. |
| Strv-101 | Stridsvagn-101, UK-made Centurion in Swedish Army. |
| Strv-102 | Stridsvagn-102, UK-made Centurion in Swedish Army. |
| Strv-103 | Stridsvagn-103, Swedish-designed turretless tank. |

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| Superelevation | Difference between elevation to target and desired gun elevation to fire on target. |
| Swingfire | UK ATGM |
| Synchrotransformer | Electric motor circuit used as transformer. |
| T-54 | Soviet tank built from 1940s to 1960s. |
| T-55 | Soviet tank built from 1950s through 1970s. |
| T-62 | Soviet tank built from 1960s to 1970s. |
| T-64 | Soviet tank built since late 1960s. |
| T-72 | Soviet tank built since early 1970s. |
| T-80 | Newest deployed Soviet tank, built since early 1980s. |
| TAM | Tank-Argentina-Medium; German-designed, Argentine-produced tank. |
| TH-301 | Private-venture tank designed by Thyssen-Henschel. |
| Thermal imager | Passive imaging sight sensitive to IR radiation in 8- to 14-micron range. |
| Thermal sleeve | Insulation around gun barrel to minimize warping caused by uneven heat distribution. |
| Thomson-CSF | French firm making electronic and night-vision devices. |
| Throwoff | Predictable tendency of muzzle to jump to one side upon firing. |
| Thyssen-Henschel | German firm making armored vehicles. |
| TLS | Tank laser sight; optical tank sight with built-in laser rangefinder; made by Barr and Stroud. |
| Traverse | Turret rotation. |
| Traverse offset | Difference between azimuth to target and desired turret azimuth to fire on target. |
| TRU | US designator for thermal receiving unit; thermal imager built into US M1 gunsight. |
| Tsiklon | Soviet designator for stabilized gun drive in T-54 and T-55. |
| TTS | Tank thermal sight; thermal imager in US M60A3 gunsight. |
| Type 59 | Chinese copy of T-54 tank. |

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| Type 61 | Japanese tank built in 1960s. |
| Type 69 | Improved Chinese tank, currently being produced. |
| Type 74 | Japanese tank built in 1970s. |
| Type 88 | Newest Japanese tank design, scheduled for production in late 1980s. |
| Valiant | Latest Vickers private-venture tank. |
| Vasconcellos | Brazilian firm making optical tank sights. |
| Vickers | UK firm making armored vehicles. |
| Vickers Mark 1 | Vickers private-venture tank of 1960s. |
| Vickers Mark 2 | Vickers private-venture tank of 1970s. |
| Vickers Mark 3 | Vickers private-venture tank of late 1970s-early 1980s. |
| Vijayanta | UK-designed Vickers Mark I tank built in India. |
| Visible light | Light with wavelengths from 0.4 to 0.7 microns. |
| Watervliet | US arsenal making large-caliber guns. |
| WBG | West German designator for thermal imager in Leopard II. |
| Wegmann | German firm making grenade launchers. |
| Wild Heerbrugg | Swiss firm making optical tank sights. |
| X-30 | Press name for Brazilian 30-ton tank. |
| Zahnrad Fabrik | Zahnradfabrik Friedrichshafen; West German automotive firm chosen for South Korean ROKIT transmission. |
| Zeiss | Carl Stiftung Zeiss; West German firm making optical tank sights and fire-control systems. |



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Appendix B

Tutorial on Tank Fire-Control Technology

Technical Considerations

Tank fire-control systems consist of devices to find and designate targets for engagement (acquisition and designation) and to aim and fire the tank guns (gunnery). Acquisition and designation devices establish a line of sight from a tank to a target. Gunnery devices determine and implement the direction the gun must aim to fire a round on a path to the target (see figure B-1).

The direction of aim is defined by a set of angles from a reference. The line of sight from the tank to the target is normally the reference. The angles between the line of sight and aiming direction must be measurable in terms of turret traverse and gun elevation. The most common angles used are the traverse-offset angle in the plane of turret traverse and the superelevation angle in the plane of gun elevation. Angles external to the tank, such as the geographic azimuth and elevation angles from its gun to a target, are not used in tank gunnery because, during a battle, tanks do not have the time or equipment to fix their positions and direction-references accurately enough for gunnery.

The simplest tank fire-control system is a telescope strapped to a gun and hand-cranked traverse and elevation gears (see figure B-2). The commander visually acquires and orally designates targets; the gunner steers the gun until the target is centered in the telescope and then fires. Many deployed tanks have such fire-control systems. More recently designed systems are more complex, integrated, and technologically advanced to provide higher accuracy and firing rates under more demanding battle conditions. No matter how advanced, fire-control devices can be classified in terms of the traditional acquisition and designation role of the commander and the gunnery role. The only complication is that some sights can be used in both roles.

Fire-Control Functions and Devices

Requirements for operation under different battle conditions determine the technical characteristics and

complexity of fire-control devices. Fire-control systems must meet different requirements for four basic tank-to-target geometries:

- A stationary tank firing at a stationary target.
- A moving tank firing at a stationary target.
- A stationary tank firing at a moving target.
- A moving tank firing at a moving target.

Many modern tanks can perform well if only the tank or the target is moving, but firing at a moving target from a moving tank is more technically demanding.

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In addition to meeting these basic requirements, fire-control systems may be required to provide the capability to fire at very long range, at night, in periods of obscured visibility, or rapidly at many targets. Other requirements such as ruggedness, maintenance, logistics, adaptability, and cost constraints compound the technical design problems. A well-designed, battle-worthy fire-control system should continue to provide some performance even after some parts of it have failed or been destroyed.

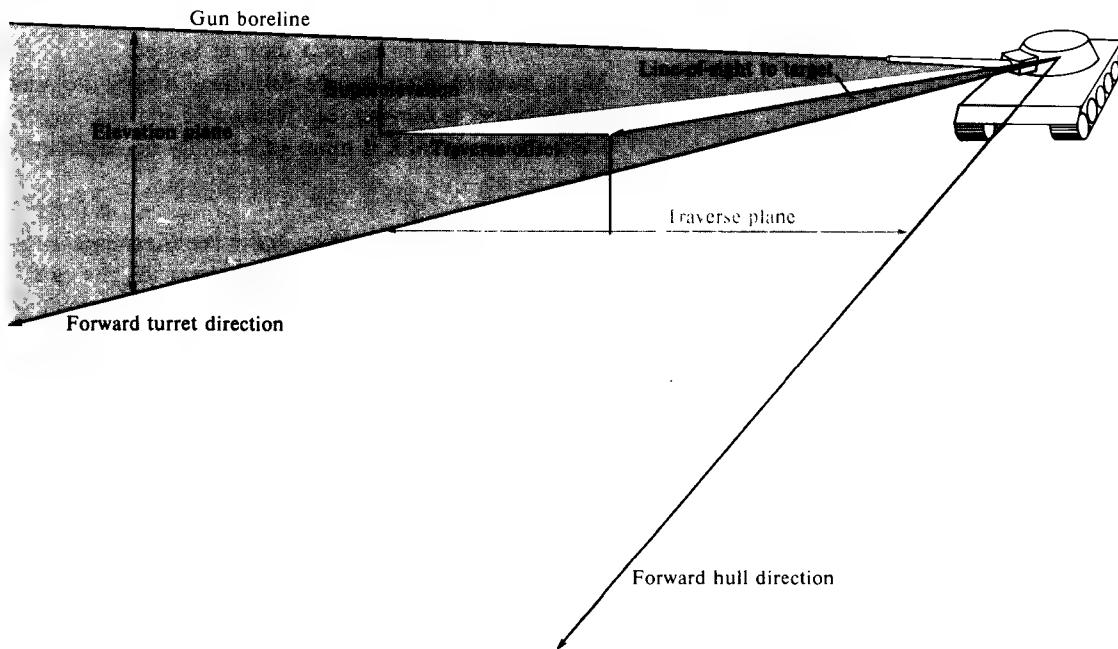
The sequence from acquisition to firing can be divided into seven steps:

- *Acquisition*. Finding a target.
- *Designation*. Transferring target line of sight from acquisition sights to gunner.
- *Ballistic data entry*. Entering into the ballistic computer the necessary information to compute aiming angles.
- *Ballistic computing*. Calculating aiming angles based on ballistic inputs.
- *Ballistic driving*. Indicating the aiming angles to the gunner.
- *Gun driving*. Driving the gun to the aiming angles.
- *Firing*.

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Figure B-1
Tank Fire-Control Coordinates



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Fire-control components serve one or more of these functions. Components include a variety of sights, searchlights, cupolas, ballistic-input sensors, computers, ballistic drives, and gun drives. [redacted]

RMGs combine ballistic data entry, computing, and driving. The RMGs are linked to the main guns and fire bullets that are ballistically matched to the main ammunition up to a certain range. The RMG bullets follow the path to a target that the main rounds would follow if fired at the same elevation. As the gunner fires the RMG, he continues to elevate both the RMG and main gun. When the RMG bullets begin striking the target, he fires the main gun. [redacted]

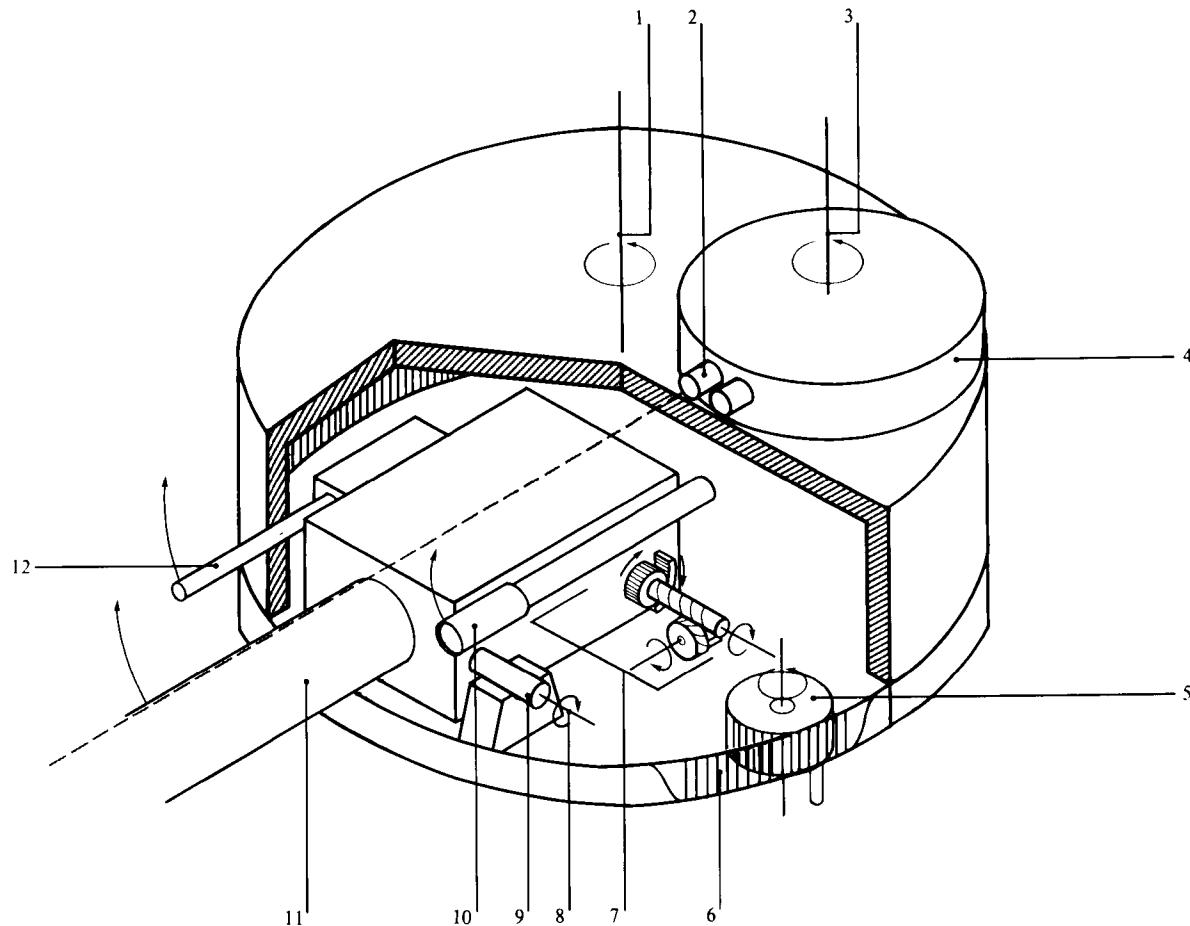
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Tank sights fit into telescopic and periscopic mounts. In the simplest fire-control systems, the telescopes strapped to the guns are called coaxial telescopes. Coaxial telescopes bypass computation and ballistic driving because they contain precomputed aiming marks (see figure B-3). The aiming marks form a vertical scale marked with ranges. The gunner usually elevates the gun until the mark that most closely corresponds to the estimated range is on target. [redacted]

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Figure B-2
Simple Tank Fire-Control System



1. Turret traverse axis
2. Commander's sight
3. Cupola traverse axis
4. Commander's cupola
5. Traverse handwheel
6. Toothed turret base
7. Elevation handwheel and gear mechanisms
8. Gun elevation axis
9. Trunnion
10. Coaxial telescope
11. Main gun
12. Coaxial machinegun

— — — Commander's line-of-sight to target
 Gunner's line-of-sight to target

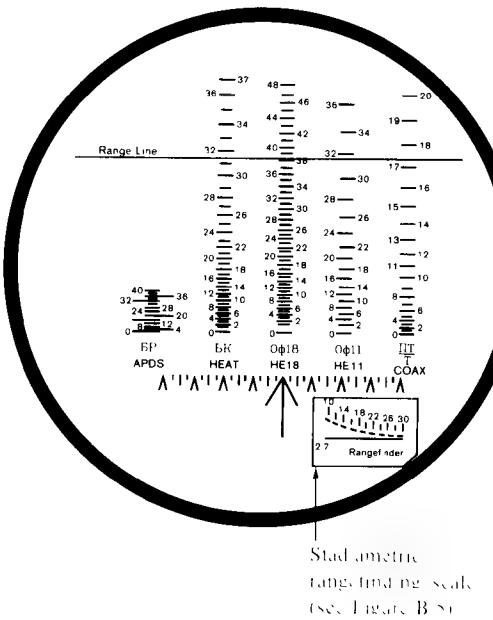
— — Traverse movements
 — — Elevation movements

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Figure B-3
Aiming Scales in Coaxial Telescope Reticle^a

Cupolas are small domes on top of the turret intended to give commanders a higher, all-round view to aid acquisition. Commander's sights are mounted in the cupolas. Gunners sit lower inside the turret and do not have an all-round view.

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^aThe example is a TSh 2B-41U telescope used in the Soviet T-62. The range line shown would be used to fire a HEAT round to about 3,150 meters range, a high-explosive HE18 round to about 3,825 meters range, a high-explosive HE11 round to about 3,175 meters range, or coaxial machinegun rounds to about 1,740 meters range.

Periscopes are often used for gunnery instead of coaxial telescopes. The periscopes are linked to the gun with mirror, lever, and servomotor mechanisms (see figure B-4). Many sights contain image converters or image intensifiers for night vision. Image converters require near-IR light, which is provided by filtered searchlights. Image intensifiers only require faint natural light from stars. LLLTV systems and thermal imagers can be used during both day and night. Thermal imagers also can detect targets at night and through dust, smoke, haze, rain, and some types of camouflage.

Target range and ammunition type are the most important ballistic inputs. There are stadiametric, coincidence, stereoscopic, correlation, and laser rangefinders. A stadiametric rangefinder is a scale, marked inside a sight, consisting of vertically separated pairs of lines (see figure B-5). Each pair corresponds to a range, and its separation indicates the visual size of a tank-size vehicle at that range. The user finds the closest fit of an enemy tank between the lines and reads the range estimate on the scale. Coincidence, stereoscopic, and correlation rangefinders require that a target be viewed from opposite ends of an optical base (see figure B-6). They use the slightly different views of the target to find ranges. The magnitude of the angles depends on range. Coincidence and stereoscopic rangefinders with wide baselines are more accurate than those with narrow baselines. Coincidence and stereoscopic rangefinders on tanks often have a 2-meter base extending across the turret. Correlation rangefinders are designed to use shorter bases—about a third of a meter. Laser rangefinders require no base and work by measuring the time interval for a laser light pulse to travel to a target and return. Many rangefinders are integral parts of commander's or gunner's sights and are not mounted separately.

Tanks fire several types of ammunition: nonexploding AP, HE, HEAT, HESH rounds with high-velocity FS, DS, and fragmentation modifiers. Each type has different flight characteristics that must be compensated for in the fire-control process.

Other ballistic inputs can influence accuracy (see figures B-7 and B-8). These include target motion (usually sensed by a turret traverse-rate sensor), turret and gun position, tank speed, wind velocity, air pressure, air temperature, ammunition charge temperature, variations in characteristics within a batch of

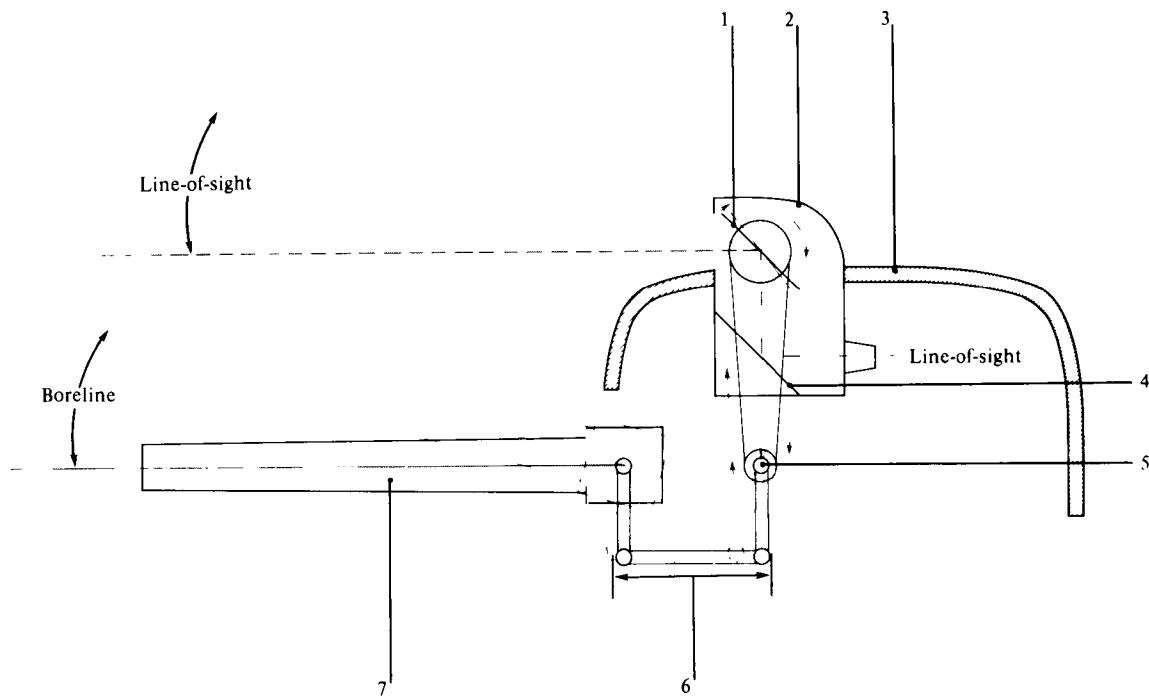
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Figure B-4
Tank Gunnery Periscope



1. Movable mirror
2. Periscope
3. Turret armor
4. Fixed mirror
5. Fixed pulley
6. Mechanical linkage
7. Gun

Note: not to scale.

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ammunition, gun-barrel droop or warp, alignment and parallax errors between sights and guns, and the amount of turret tilt (cant). Sensors that monitor these inputs are being aggressively marketed with new fire-control systems, but their value is questioned by many fire-control scientists.

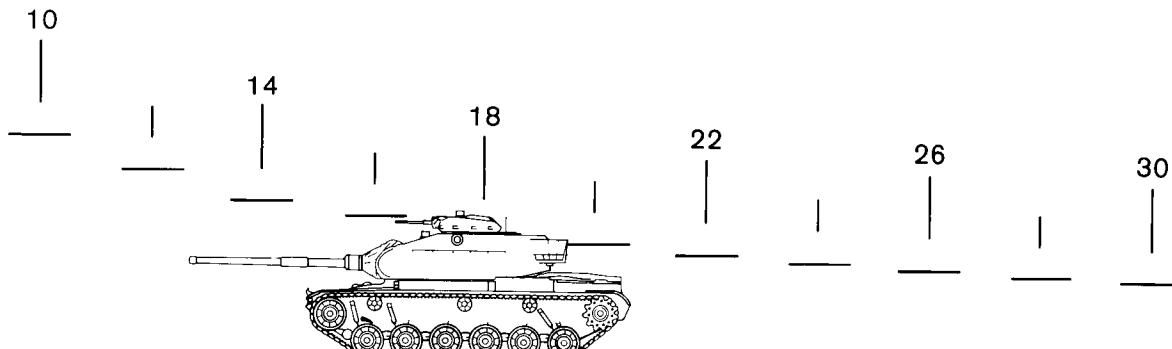
Tank ballistic computers are specialized mechanical, analog electronic, or digital electronic computers.

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Figure B-5
Stadiametric Rangefinding Scale



2.7

Lower left number indicates an assumed target height of 2.7 meters.

Target shown is an M60A1, measuring about 2.7 meters to the top of the turret, at 1,800 meters range.

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Gun drives are the heavy machinery that traverses the turrets and elevates the guns. The simplest gun drives are manual gear trains. Since the 1950s gun drives have been electrically powered (all electric) or hydraulically powered with electric controls (electrohydraulic).

Ballistic drives are the links between computers, gun drives, and gunner's sights and are used to indicate aiming angles to the gunner. Typically, ballistic drives are mechanical links, servomotors, or electronic circuits that deflect a crosshair-type mark (reticle) in the gunner's view. The gunner traverses and elevates the gun drive to bring the reticles back to center.

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Gun-drive machinery often includes stabilizing circuits to aid firing on the move. Stabilizers hold the gun on a steady inertial azimuth and elevation as the tank moves; they do not keep the gun directed at a target. The stabilizing circuits use gyroscopes to provide azimuth and elevation references and feedback circuits to keep driving the gun toward the desired angles. Stabilizing circuits can be very sophisticated and are often controlled by onboard ballistic computers.

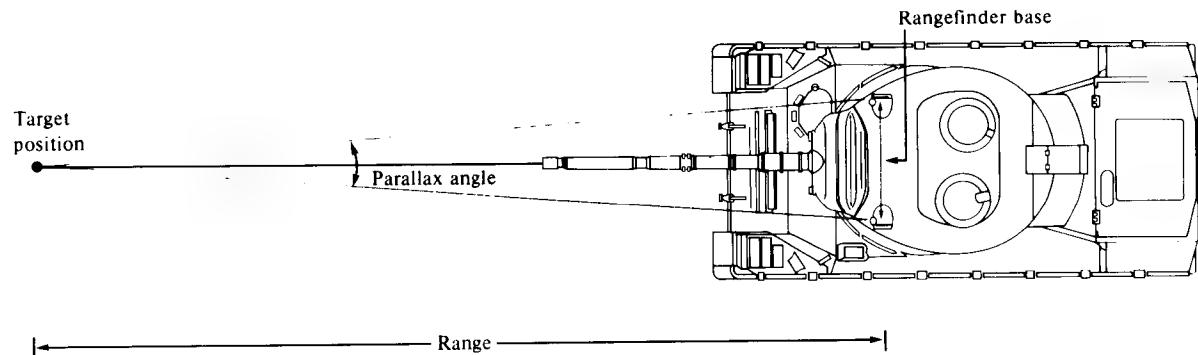
Tank sights can be gyroscopically stabilized independently of the gun drive. Nonstabilized gunnery sights follow the gun. A stabilized sight maintains a steady view as the tank moves, allowing observation, target acquisition, or aiming on the move. The gun drive must be stabilized, however, for firing on the move.

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Figure B-6
Example of Coincidence Rangefinder^a



^aThe tank shown is a German Leopard IA2.

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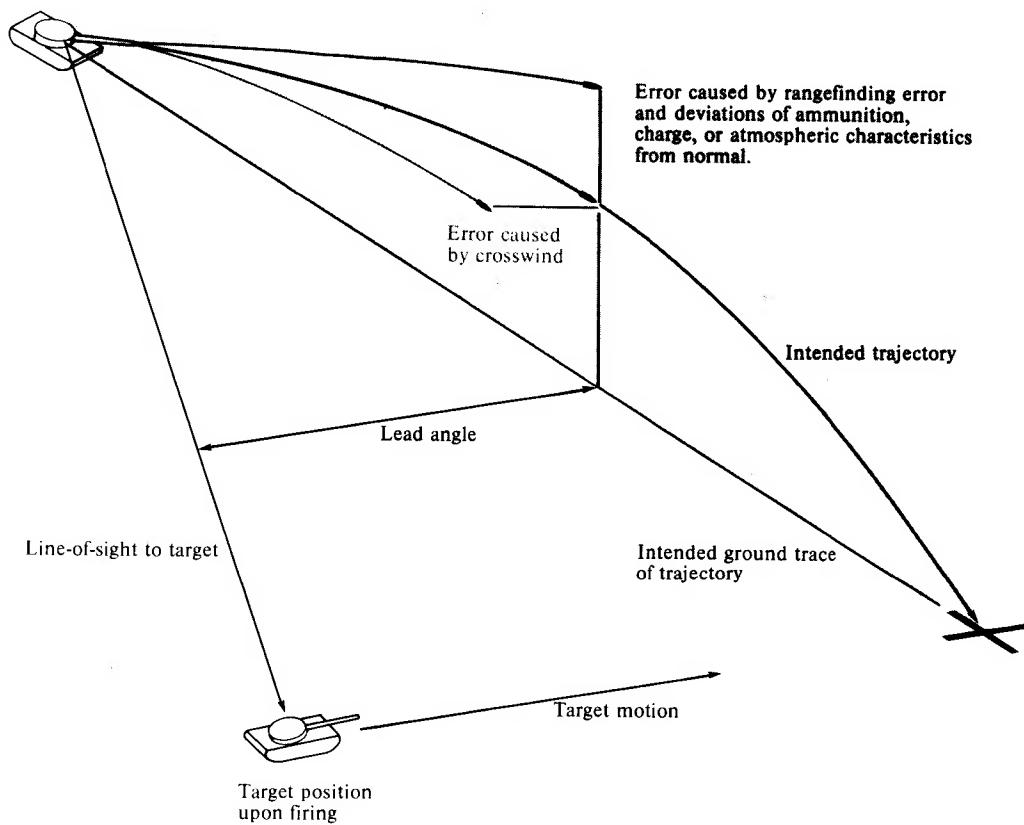
Some modern tanks, such as the West German Leopard II and US M1, have both stabilized sights and guns. In this case, the sights are independently stabilized. The feedback circuits drive the guns to follow the sights

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Firing at a moving target from a moving tank requires stabilized gun drives and sights that are controlled by a ballistic computer.

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Figure B-7
Influences on Trajectories of Tank-Fired Projectiles

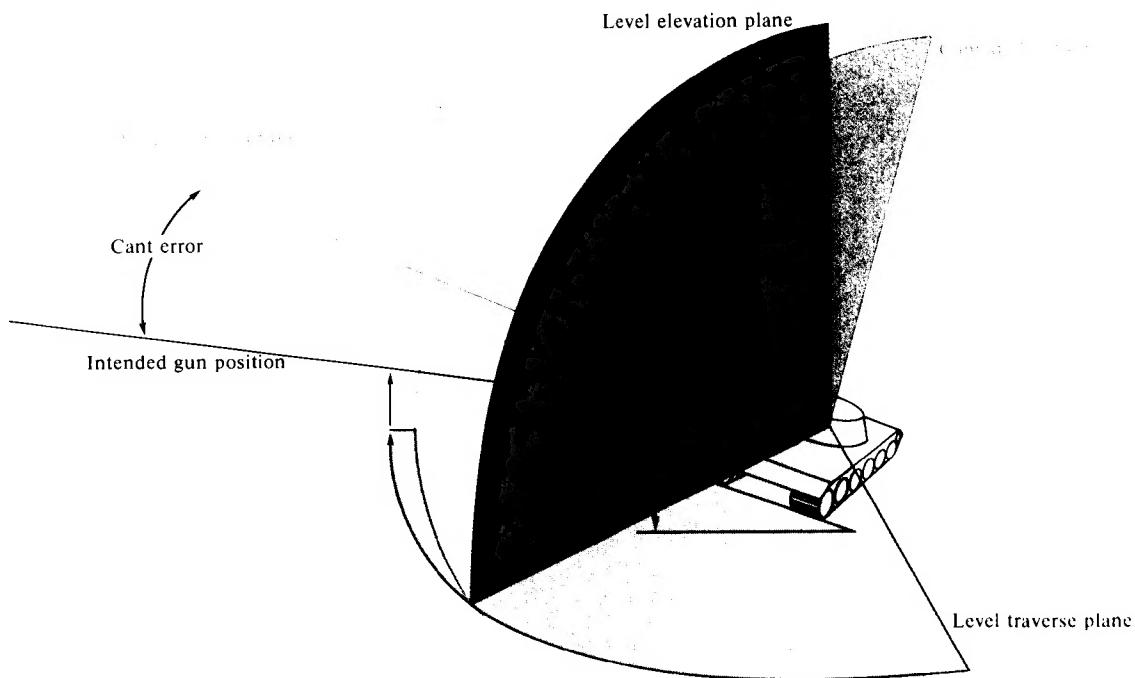


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Figure B-8
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